VALUATION OF NATURAL RESOURCES: A Critical Examination of Economic Valuation Approaches used in Estimating the Value of Biodiversity

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EXECUTIVE SUMMARY

'Biological diversity' (biodiversity) is an umbrella term used to describe the number, variety and variability of living organisms in a given assemblage. Biodiversity may be described in terms of genes, species and ecosystems, relating to the three fundamental and hierarchically related levels of biological organisation. It therefore embraces the whole of 'Life on Earth'. Declines in biodiversity include all those changes, which will reduce or simplify biological heterogeneity, from individuals or regions.

It is hard to use the term *biodiversity* for valuation. Diversity valuation requires some idea of willingness-to-pay (WTP) for the range of species and habitats. In reality, what economic studies are normally measuring is the economic value of *biological resources* rather than biodiversity.

Biological resources are a more anthropocentric term for biota such as forest, wetlands and marine habitats. They are simply those components of biodiversity which maintain current or potential human uses. This anthropocentric view of biological resources is much more convenient for economic analysis compared to alternative value paradigms such as intrinsic values (values in themselves and, nominally unrelated to human use). Intrinsic values *are* relevant to conservation decisions, but they generally cannot be measured.

Studies of biological resources may capture diversity values; for example, studies valuing habitat may capture perceptions of biodiversity (i.e., valuations may be high simply because the area is known to be rich in diversity) but such effects are difficult to assess.

There are other reasons why it is difficult to put a monetary estimate on biodiversity. The lack of consensus on the rate of biodiversity loss and biodiversity indicators, and of any baseline measurements of biodiversity also has important implications for economic valuation. Fundamental to any monetary measure of value is some index or set of indices of biodiversity change.

Biodiversity conservation and sustainable development issues are major international concerns. Recently, conservation of biodiversity has been recognised in the international community, including policy makers and scientists, as essential for the very survival of human beings in the planet.

The central problem addressed in this research effort is to refine the valuation methodologies applicable to biodiversity, and derive recommendations for more accurate estimates of the value of biodiversity. This study therefore attempts to critically examine a range of methodological issues that pertain to economic valuation of biodiversity. At the moment there is only anecdotal evidence that biodiversity is valuable on a global basis. It is by no means clear how much particular countries or communities benefit or lose under the current regime. Neither is it clear which countries stand to gain or lose if the current situation is changed.

This study reviews the literature on the economic valuation approaches used in estimating the value of biodiversity. Methodological issues are noted, as well as difficulties highlighted by many authors in theory and practice in employing these methods. This study also looks at issues associated with multiple valuations of biodiversity.

The case studies selected present a summary of practical economic valuation studies conducted from a range of geographical regions. Efforts more closely resembling Total Economic Valuation, in which an attempt is made to value all functions of biodiversity, are also represented.

Most methodology classifications focus on how benefits are measured, and thus distinguish between `direct' vs. `indirect' methods. These categories are not related to direct or indirect use benefits, but relates instead to the way information is collected.

Results of the analysis of the selected case studies have shown that a very wide range of value estimates can be derived, depending on the technique used and what is being investigated.

In general, three quite different `classes' of biodiversity value are usually estimated. The study adopted the following classes of values:

A) Biodiversity production values

B) Biodiversity utility values

C) Biodiversity rent capture values.

A number of lessons can be drawn from the experience derived from valuing and trying to capture biodiversity. First, the actual value associated with biodiversity may be closely tied to the type of information that it provides, as opposed to any particular material good. In some cases this information provides a stock of ideas that can be used to synthesize key compounds; this occurs largely in the pharmaceutical industry. In other cases the information itself provides direct genetic information that can be introduced into other economic species; this occurs largely in the field of plant genetic resources.

The second lesson is that a large array of values can be estimated, depending upon the type of technique used; it is therefore important to understand the limitations and applications of any given technique.

Finally, and perhaps most important, proper interpretation of the different values can provide important policy implications. For example, the simple comparisons listed above generally demonstrated that techniques based on `human life' generated the highest valuations whereas those relying on `capturable benefits through royalties or patents' generated the lowest values. The low value of transfers is a chronic problem with inventions and information.

SUPERVISORS SIGNATURE PAGE

I, Omunga Philip Magaga, hereby declare that this research project is my original work and has not been presented for a degree in any other University.

Mr. Omunga, Philip Magaga

The Supervisors appointed to examine the Research Project of Omunga Philip Magaga find it satisfactory and recommend that it be approved.

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1.1 BACKGROUND TO THE PROBLEM

Biodiversity value includes direct and indirect use values, option and existence value. The valuation of preferences for biodiversity is perhaps the most challenging issue in the context of economic valuation.

'Biological diversity' (biodiversity) is an umbrella term used to describe the number, variety and variability of living organisms in a given assemblage. Biodiversity may be described in terms of genes, species and ecosystems, relating to the three fundamental and hierarchically related levels of biological organisation. It therefore embraces the whole of 'Life on Earth'. Declines in biodiversity include all those changes, which will reduce or simplify biological heterogeneity, from individuals or regions.

It is hard to use the term *biodiversity* for valuation. Diversity valuation requires some idea of willingness-to-pay (WTP) for the range of species and habitats. In reality, what economic studies are normally measuring is the economic value of *biological resources* rather than biodiversity.

Biological resources are a more anthropocentric term for biota such as forest, wetlands and marine habitats. They are simply those components of biodiversity which maintain current or potential human uses. This anthropocentric view of biological resources is much more convenient for economic analysis compared to alternative value paradigms such as intrinsic values (values in themselves and, nominally unrelated to human use). Intrinsic values *are* relevant to conservation decisions, but they generally cannot be measured. Studies of biological resources may capture diversity values; for example, studies valuing habitat may capture perceptions of biodiversity (i.e., valuations may be high simply because the area is known to be rich in diversity) but such effects are difficult to assess.

There are other reasons why it is difficult to put a monetary estimate on biodiversity. The lack of consensus on the rate of biodiversity loss and biodiversity indicators, and of any baseline measurements of biodiversity also has important implications for economic valuation. Fundamental to any monetary measure of value is some index or set of indices of biodiversity change.

The projected loss of species over the next century might be as high as 20%-50% of the world's total which represents a rate between 1000-10, 000 times the historical rate of extinction (Wilson 1988). The implications of species depletion on the functioning of vital ecosystems are not clear. Possible worst case scenarios involve the existence of depletion thresholds and associated system collapse. Such outcomes clearly indicate the interaction between the environment and the economy. More immediately, the loss of biological resources might be apparent in decline in cultural diversity, indices of which are provided in diet, medicine, language and social structure.

It is reported that about half of the world's species are contained in just seven percent of the planet's land surface (WRI, 1997a). That means the pressure on terrestrial biodiversity is intense and it increases as human population needs for space grow over time.

The population of the Earth will likely double by the year 2050, resulting in a world of at least 10 billion people, the largest number of whom, by far, will live in tropical and subtropical Asia, Africa, and South America. These are as well the regions in greatest need of economic development, and the twin pressures of population growth and economic expansion can only increase the demands on natural resources and specifically biological resources. We can anticipate an ever-increasing competition among different uses of the available land, and the maintenance of biodiversity may not rank high in the face of other, more obvious demands.

Based on recent estimates of land-use change, largely in the tropics, there is a reasonable expectation that extinction rates in the very near future could rise, worldwide, to as much as 10,000 times the natural level.

In order to accurately estimate Total Economic value of biodiversity, it is imperative that a reasonably accurate and reliable method (or methods) be developed. In the absence of some reliable method for estimating the value of biological resources, the price received by the provider is largely determined by market practice. Given the lack of experience and precedent in many of the markets for biodiversity, it is unlikely that the value these markets give to the resource will reflect the full value placed on it by society. The experience in other markets for primary or raw materials is that rarely, if ever, do the suppliers receive optimal value for the resource.

From an economic perspective, much more work needs to be done to put a fair and meaningful valuation on biodiversity. The service aspects of biodiversity must be understood, and market mechanisms put in place to include these very real factors in both policy and business decisions. From a scientific perspective, we need to learn more, and more quickly, about the role that biodiversity plays in the working of ecosystems. Gaps in our present knowledge of these connections now limit our assessments of the risks imposed when biodiversity declines, and preclude more complete economic evaluations.

1.2 STATEMENT OF THE PROBLEM

The central problem addressed in this research effort is to refine the valuation methodologies applicable to biodiversity, and derive recommendations for more accurate estimates of the value of biodiversity.

At the moment there is only anecdotal evidence that biodiversity is valuable on a global basis. It is by no means clear how much particular countries or communities benefit or lose under the current regime. Neither is it clear which countries stand to gain or lose if the current situation is changed.

An understanding of the full range of values associated with biodiversity, is a foundation for making informed choices about its conservation and sustainable use. Only when this full range of values is understood can valid policy choices be made between the conservation and sustainable development of biodiversity, and competing factors such as the timber value of forests or the alternative use values.

1.3 RESEARCH OBJECTIVES

The general goal of this study is to assign reliable value to biodiversity. One of the challenging aspects of this valuation is to assign a value to 'biodiversity rich land' itself. This study attempts to: -

- Examine a range of methodological issues that pertain to economic valuation of biodiversity functions.
- Examine the application of economic valuation methodologies in estimating the value of biodiversity rich land.
- Recommend way forward

1.4 RESEARCH HYPOTHESIS

Null Hypothesis: A large array of values can be estimated, depending upon the type of valuation technique used.

1.5 SCOPE OF THE STUDY

This study will review recent case studies and research undertaken for the last 10 years from the year1980 to 2000. The study will examine a range of methodological issues that pertain to economic valuation of biodiversity functions focussing on the application of the current Valuation Methodologies on estimating Total Economic Value (TEV) of biodiversity. Finally the study focuses on proper understanding of underlying institutions and procedures which facilitate consistent valuations for decision making.

1.6 SIGNIFICANCE OF THE STUDY

An understanding of the full range of values associated with biodiversity is a foundation for making informed choices about its conservation and sustainable use. Only when this full range of values is understood can valid policy choices be made between the conservation and sustainable development of biological resources, and competing factors such as the timber value of forests or the alternative use values. Perhaps even more importantly, such an understanding can help illuminate the possible avenues for creating a better harmony between what has heretofore been seen as these competing alternatives. This study thus endevours to achieve the above.

1.7 SOURCES OF INFORMATION AND METHODS OF RESEARCH

The main focus of this study is to critically examine economic valuation approaches used in estimating the value of biodiversity. The study is based on available secondary source materials. The secondary sources include diverse literature on economic valuation of biodiversity functions. The analyses draws upon practical case studies review. References to reports, case studies and project evaluation form the basis for an analysis of the economic valuation approaches used in estimating the value of biodiversity.

1.8 ORGANIZATION OF THE STUDY

Chapter 1 has presented the abstract, background to the problem, statement of the problem, research objectives, research hypothesis, scope of the study, significance of the study, study methodology and procedures, organization of study and definition of terms. Chapter 2 contains the review of related literature and research related to the problem being investigated. The summary of selected case studies, results of analyses and findings to emerge from the study are contained in Chapter 3. Chapter 4 contains a summary of the study and findings, conclusions drawn from the findings, a discussion, and recommendations for further study.

1.8 DEFINITION OF KEY TERMS

Access to genetic or other natural resources means the admission for collecting, obtaining or otherwise acquiring genetic or other natural resources.

Benefits Sharing- Means all forms of compensation for the utilization of genetic resources whether monetary or non-monetary, and includes, in particular, the participation in scientific research and development on genetic resources, and the making available of the findings such scientific research and development and the transfer of technologies (Swiss State Secretariat for Economic Affairs et al. 2000).

Biodiversity - Defined by the Convention on Biological Diversity, as the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are a part: this includes diversity within species, between species, and of ecosystems.

Contingent Valuation- a valuation from a survey technique using direct questioning of individuals to estimate individuals willingness to pay.

Cost-benefit analysis- the appraisal of all the social and economic costs and benefits accruing from a decision or project.

Demand- the desire for a good or service supported by the means to purchase it.

Developing country- a country that has not yet reached the stage of economic development characterised by the growth of industrialization, nor a level of national income sufficient to yield the domestic savings required to finance the investment necessary for further growth.

Diminished biological components - A reduction in the diversity of biological species. An ecosystem is considered to have both biotic and abiotic elements. Many species of microflora or insects are very important to soil building, plant reproduction, or nutrient cycling. The biotic elements are dynamic in occurrence and will change in response to natural vegetation succession or artificially induced changes. The concept of diminished biological components reflects reductions or shifts in biological processes in a given forest relative to what might be expected, based on an undisturbed, similar reference site.

Direct use value- the value derived from direct use of genetic resources.

Discount rate- the calculation of present value by application of a discount rate to a capital sum.

Economic efficiency- the allocation of resources in the economy that yields an overall net gain to society as measured through valuation in terms of the benefits of each use less its costs.

Ecosystem - A dynamic complex of living organisms (plant, animal, fungal and micro-organism communities) and the associated non-living environment with which they interact.

Ecosystem diversity- Describes the variety of different ecosystems found in a region. A categorization of the combination of animals, plants, micro-organisms, and the physical environment with which they are associated is the basis for recognising ecosystems.

Genetic resources means " genetic material of actual or potential value". " Genetic material means any material of plant, animal, microbial or other origin containing functional units of heredity" (CBD, Article 2).

Indirect opportunity cost- the time spent on an activity, valued in terms of forgone opportunities.

Indirect use value- indirect support and protection provided to economic activity and property.

Intrinsic value- the worth of something in itself regardless of whether it serves as an instrument for satisfying individuals' needs and preferences.

Market- a collection of transactions whereby potential sellers of a good or service are brought into contact with potential buyers and the means of exchange is available.

Net present value- the discounted value of a financial sum at some point in the future due to financial flows over a number of years from, for example, interest.

Non-use value- the value derived neither from current direct nor from indirect use of genetic resources.

Opportunity cost-the value of that which must be given up to acquire or achieve something.

Public good- where one individual may benefit from the existence of some environmental good or service without reducing the benefit another individual can receive from the same good or service.

Species diversity - Describes the number and variety of species flora and fauna in a given area.

Surrogate market price- the use of an actual market price of a related good or service to value non-marketed genetic resources.

Total valuation- assessment of the total economic contributions. Or net benefits to society of genetic resources

Supply- the quantity of good or services available for purchase.

Valuation- estimation or quantification of the values of a property, good or service.

Value- the worth of property, good or service, generally measured in terms of what we are willing to pay for it, less what it costs to supply it.

Willingness to pay- the amount that someone is prepared to pay to purchase a good or use of a service regardless of whether there is a prevailing market price or the good or service is available free of charge.

CHAPTER II: LITERATURE REVIEW

2.1 Brief Historical Overview: -The Evolution of Natural Resource Value

Value has been a central concept throughout economic history. The earliest modern economic paradigm, the mercantilist, defined value through precious metals. To secure vast amounts of valuable but useless precious metals (which were used only for coinage), nations following the mercantilist paradigm devoted much of their labor both to mining for the minerals and to producing low priced exports for favorable mineral trade (Daly, 1993a).

The physiocrats, a subsequent school of thought, emerged in France in the 18th century and like the mercantilist held a physical basis of value, but expanded it from precious minerals to agriculture. The physiocrats viewed land as the only productive source, while labor and capital only enhanced its productivity and added no value of their own. The theory could not explain non-material yet economically observable concepts such as interest and had difficulties in tracing all value back to land. This led to the classical economic paradigm.

Classical economists, beginning with Adam Smith in the 18th century, shifted the source of value to labor. In the Wealth of Nations, Smith states, " the value of any commodity is equal to the quantity of labor which enables him to purchase or command. Labor therefore is the real measure of exchangeable value of all commodities". The idea of differential labor productivity led to the formulation of two economic concepts important to Natural resource valuation: diminishing returns and economic rent. The depressing outlook of the classical paradigm, in turn, led to an economic paradigm with more optimistic world view, the Neoclassical.

Neoclassical theory differed from all previous economic paradigms by shifting the derivation of value from production to consumption. The neoclassicists focused on use value based on subjective human wants (Pearce and Turner, 1991; Samuelson and Nordhaus, 1992; Cristensen, 1989).

Because of the complexity and ubiquity of many Natural resources, neoclassical value theory sometimes cannot provide tools to properly value the goods and services which resources provide. Environmental economists have developed techniques such as Contingent valuation to measure the compensating variation, or willingness to pay (WTP), for natural resources which are not priced in a market.

2.2 Valuation of Natural resources

Discussion of economic valuation and the role of future generations' preferences may seem remote from the concerns of the developing economies. But valuation is fundamental to the notion of *sustainable development*. If sustainable development is very loosely defined in the sense of the World Commission on Environment and Development (the Brundtland Commission, see World Commission on Environment and Development [1987]) as development that: " ...meets the needs of the present without compromising the ability of future generations to meet their own needs." then it is clearly fundamental to know what is and what is not a sustainable development path. It should be possible to see that a development path which ignores the environmental consequences of economic change may well be unsustainable.

According to Brown and Moran (1994), the economic valuation of biodiversity is required for the purpose of placing this "common concern" within a global operational and management context by which its current and future status can be controlled. Such an economic context does not imply that biodiversity is devoid of intrinsic values, nor, the authors suggest, do the attempts to quantify biodiversity negate its global value. Rather, economic valuation is a process by which policy can be altered or created to enhance the current condition of biodiversity, and reverse the current course of its depletion. As a result, the co-existence of intrinsic environmental values and economic values are equally legitimate, and (at least in theory) equally relevant to international, state, and local decision-making (Brown and Moran, 1994).

According to Pearce and Moran, however, the reality is that economic forces drive much of the destruction and extinction of the world's biological resources and diversity that occurs today. They identify this reality as resulting from a market failure based on an economic failure to capture the actual value of the resources. This in turn produces misguided decisions and destructive policies pertaining to biodiversity. In this context, economic valuation can be a principal shaping force of conservation efforts by working to convert economic disincentives for biodiversity protection into economic incentives. A proper understanding of the full range of economic values could reverse this undervaluation by allowing appropriate economic inducements to improve the value of biotic resources, thereby allowing the host country to achieve full and equitable economic benefits from them. This approach provides a somewhat more pro-active role for economic valuation in the development and justification of policy and legislation at the national and international levels (Pearce and Moran, 1994).

2.3 The Valuation of Biodiversity

2.3.1 Economic valuation

It is important to understand what is being done when economic valuation is carried out. The economic value of something is measured by the summation of many individuals' willingness-to-pay for it. In turn, this willingness-to-pay (WTP) reflects individuals' preferences for the good in question. So, economic valuation in the environment context is about 'measuring the preferences' of people for an environmental good or against an environmental bad. Valuation is therefore of preferences held by people. The valuation process is anthropocentric. The resulting valuations are in money terms because of the way in which preference revelation is sought -- i.e. by asking what people are willing to pay, or by inferring their WTP through other means. Moreover, the use of money as the measuring rod permits the comparison that is required between 'environmental values' and 'development values'. The latter are expressed in money terms, either in a dollar amount or an economic rate of return. Using other units to measure environmental values would not permit the comparison with development values.

The most common economic modelling for the valuation of biodiversity is called Total Economic Value (TEV) which derives from "use value" (UV) and " non-use value" (NUV). Use value (UV) may be direct (DUV), indirect (IUV), or optional (OV). Direct use values are derived from the actual use of the resource, such as timber in a forest, recreation, fishing, etc. Indirect use values refer to the benefits derived from ecosystem functions, such as a forest's function in protecting a watershed, or as a carbon sink against global warming. Optional value is a value approximating an individual's willingness to pay to safeguard an asset for the option of using it at a future date. Non-use values (NUV), are seen as more problematic in definition and estimation. They are divided into bequest value (BV), the value to an individual of the knowledge that others will benefit from the resource in the future; and an existence or passive use value (XV), which derive essentially from the simple fact of the existence of the resource.

Total economic value can be expressed as: TEV = Direct Use Value + Indirect Use Value + Option Value + Existence Value. While the components of TEV are additive, care has to be taken in practice not to add competing values. There are trade-offs between different types of use value and between direct and indirect use values. The value of timber from clear felling cannot be added to the value of minor forest products, but timber from selective cutting will generally be additive to forest products. Consider how TEV can be used when analysing say a land use decision. Let the options be 'con' for conservation and 'dev' for development. Assume the land in question is a forest area and that development involves clearing the forest. Then, on efficiency grounds, the condition for development to be socially worthwhile (ignoring time, for convenience) is: (Bdev - Cdev) - (Bcon - Ccon) > 0.

Notice that the net benefits of conservation need to be deducted from the net benefits of development for the land use change to be warranted on efficiency grounds. That is, the true *opportunity cost* of development includes the forgone conservation benefits. From the previous discussion we know that the conservation benefits are given by TEV, so that the condition for land use change becomes: (Bdev - Cdev) - (TEV - Ccon) > 0.

From the standpoint of society, the fact that some components of TEV may not accrue as cash flows is not relevant. It is artefacts that some goods and services are marketed while others are not. But from the standpoint of an effective decision, it is important that TEV be 'appropriated' as a cash flow or flow of real services. For example, if the decision is to conserve the forest because of non-market values in TEV, then the landowner will have to forgo the development benefits that accrue in cash terms. He cannot live off the invisible proceeds of TEV. As such, he will have little incentive to abide by any land use decision based on non-market values. This is why it is important to develop procedures for turning those values into cashable forms.

Pearce and Moran, in an extensive analysis of the application of this model to biodiversity issues, acknowledge that there is still no consensus as to how biodiversity can be precisely valued. This, in turn, impacts on the ability to target in the most economically effective manner the resources available for conservation and use enhancement purposes (Pearce and Moran, 1994).

The authors note, also, that Total Economic Value, as the name suggests, attempts to capture the values in an economic way, and not through spiritual, natural or other similar notions of value. They also note criticisms that the ecological functions they seek to ascribe value to may not be complete enough to indicate the full economic value in this area. Thus, they recognize that economic value measurement will understate the true economic value because of the probable failure to measure "primary life support functions."

Other approaches have also surfaced. For example, Hadley, 1994, supports a concept of "critical mass strategy", a valuation based on making full use of tropical forests' range of products and resources. This value is defined as the sum of sustainable economic activities exceeding the profits of the sum of ongoing unsustainable activities. A similar approach is taken by Balick and Mendelsohn, 1992, in arguing that many existing models have not included all the products, including those local therapeutical products not involved in international trade or traditional "market" economies.

A much less scientific method of valuing parts of the environment has come from some reviews of the Merck-INBio deal for the research and exploitation of biodiversity in Costa Rica. Pat Mooney, for example, has questioned whether the deal indicates the value of global biodiversity in stark terms. By simply comparing the immediate financial value of the Merck-INBio deal against the percentage of global biodiversity held by Costa Rica, estimated at 5%, Mooney estimates the global value of biodiversity to be about 20 million dollars US. This raises not just to the question of the global value of biodiversity, but the role of the private sector in achieving the full value (Mooney, 1993).

Economic valuation is therefore a two-part process in which it is necessary to:

(a) demonstrate and measure the economic value of environmental assets -- what we will call the demonstration process;

(b) find ways to capture the value -- the appropriation process.

2.3.2 Non-economic aspects of valuation

The approach of TEV or the other economic based valuation methods is implicitly questioned with the development of alternative "visions" of value. Social justice-oriented economists have gone beyond traditional economic models that point to market or government failures or simple causal relationships, to look to the roots of the problems in, for example, archaic institutions, unequal structures, and policies invoked in the interests of dominant groups.

Hayden calls for changing the neoclassical maximization metaphor to a metaphor that includes limits, sufficiency, policy relevance, and multi-dimensionality, emphasizing improvement rather than growth. This is consistent with the notion that sustainable development requires a greater integration of social and ecological paradigms. Hayden describes how models must accommodate not just different possible uses of an ecosystem, but also the impact those uses will have on the ecosystem itself as part of the valuation process (Hayden, 1993).

Wunderlich (1988), in evaluating Adam Smiths' Theory of Moral Sentiment (TMS) and pluralism in values as demonstrated by Lasswell and Kaplan in " Power and Society" underlines both the need and acceptability of including non-economic values in the "economic" analysis.

Various authors argue that the need is for a paradigm which does not link our health and economic welfare with biodiversity, but which characterizes us with the ability to transcend and ennoble our existence through biodiversity conservation. For instance, Linder, writing in an American social context, suggests that this grouping of values - recreation, historic, aesthetic, experiential (promoting moral or intellectual growth) - is homocentric, juxtaposed with a biocentric value of stewardship.

DiDilvestro raises the comparison between homocentric values and natural or intrinsic values via comments on Aldo Leopold's posthumous publication, *A Sand County Almanac*,

There is as yet no ethic dealing with man's relationship to land and to the animals and plants which grow upon it...The land-relation is still strictly economic, entailing privileges but not obligations." He added, "obligations have no meaning without conscience from people to land. No important change in ethics was ever accomplished without an internal change in our intellectual emphasis, loyalties, affections, and *convictions....Perhaps the most serious obstacle impeding the evolution of a land ethic is the fact that our educational and economic system is headed away from, rather than toward, an intense consciousness of land* (DiDilvestro, 1993).

Simply stated, this is the recognition of the intrinsic worth of species. An analogous paradigm, argues George (1988), is the intrinsic value of humans as seen in the Western World's commitment in national constitutions, legislation, and common law. The interconnectedness of species is seen by many as the most compelling reason for preservation of biodiversity, tying our own survival to the survival of other organisms. This argument is analogous to a house of cards whereby the removal of any one card predisposes the entire house to inevitable destruction. Countering this model, George reiterates that there is a certain randomness in nature, which may be the very constituent that protects life itself (George, 1988).

Deep ecologists express the moral imperative of conserving biological diversity for its own sake as, "humans must institute sustainable resource-use practices so that we may once again work with nature, not against it." Historical records, for example, show habitat preservation goes back at least 2000 years to India in 300 B.C., where forests were protected for wildlife. In 200 A.D., Emperor Hadrian established cedar reserves in Lebanon. And in Europe during the middle ages, forests were protected (Flevares, 1992).

Also enumerated in the literature is the value of sacredness, which is bestowed upon an area by the societies that have traditionally depended upon it. "Sacred groves are the site of ritual and secret society initiations, in them, social and political values, morals, secrets and laws are passed on to young people" (Brown and Moran, 1994). Their symbolic roles in traditional societies represent a matriarch, protector from evil spirits and provider of food, medicine and shelter, and the bridge between sky (ancestral peoples) and earth.

Pearce and Moran examine the "moral" debate, in defence of the economic role. They argue that the notion of the moral being opposed to the economic view rests "on many confusions".

First, the economic view is itself a moral view - it takes what is effectively a utilitarian approach to conservation. What the critics are complaining of is not so much the economics as the underlying philosophy of normative economics, utilitarianism. Of course, it is quite proper for such a philosophical debate to take place. The problem is that, in the absence of "meta-ethical" principles, principles that enable us to choose between apparently competing philosophies, the debate risks being rather sterile from the standpoint of getting things done (Pearce and Moran, 1994).

2.4 Economic Valuation Methodology

In order to make choices between competing wants, democratic societies use two fundamental decision making rules. The first, the Majority Voting Rule, does not take into account the strength of a persons' preferences. A second rule is therefore one where 'benefits exceed costs'. Economists look at this decision rule in terms of changes in the wellbeing or welfare of individuals as described by their 'utility' or 'preference satisfaction'. Because human well being is rather an intangible concept that cannot be directly measured, economists use a transformation of wellbeing into a more general, single scale numeraire.

This 'economic approach' involves the monetary valuation of changes in environmental quality. The task of monetary valuation of the environment is made more complex by a number of problems. These include the fact that environmental effects will often have no natural units of measurement, and even where physical indices are available these must be related to individuals' perceptions. Also, environmental effects do not often directly show up in markets due to their externality and public good characteristics. Finally, the forecasting of environmental effects is complicated by the fact that they involve bio-chemical and bio-physical feedbacks which are scientifically not fully understood.

The monetary measure of a change in an individual's wellbeing due to a change in environmental quality is called the Total Economic Value of the change in the environmental quality. It is not environmental quality per se that is being measured then, but people's preferences for changes in that quality. Valuation, as such is anthropocentric in that it is of preferences held by people, and, the value of something is established by an exchange transaction. The sum of willingness-to-pay (or total economic value) for all the individuals affected by an action is given by the area under the demand curve of the good or service that is affected.

2.4.1 Willingness-to-Pay vs Willingness-to-Accept

The task of valuation is to determine how much better or worse off individuals are (or would be) as a result of change in environmental quality or provision. Economists define the value of a change in terms of how much of *something else* (usually expressed as an amount of money) an individual is Willing-to-Pay to get this change (or how much they would be Willing-to-Accept in order to permit the change to occur). The question arises as to which measure of value -- Willingness-to-Pay or Willingness-to-Accept -- should be used for benefit estimation. Until recently, it was assumed that in most practical situations the difference between these measures would be small so long as there was an absence of strong income effects.

Willig [1976] developed a precise analytical expression of the size of this potential difference, and showed that in a wide variety of market situations, this divergence between WTP and WTA measures would be very small.

However, a substantial body of empirical evidence has recently been developed that provides convincing evidence that WTP and WTA measures are often quite different (Hammack and Brown, [1974]; Gordon and Knetsch, [1979]; Meyer, [1979]; Rowe, d'Arge, and Brookshire, [1980]; Schulze, d'Arge, and Brookshire, [1981]; Knetsch and Sinden, [1984]). Typically WTP measures turn out to be substantially less than WTA measures for the same policy change. The reaction of many economists to this evidence was to argue that the WTA results were unreliable and should not be treated seriously

(Dwyer and Bowes, [1979]; Kahneman, [1986]). The implication was that monetary estimates of well-being based on WTA measures should not be used in policy analysis.In summary, good economic analysis will require good judgement on the question of whether to use WTP or WTA measures of economic value.

2.4.2 A Review of Valuation Approaches and Techniques

There are basically two broad approaches to valuation, each comprising a number of techniques. The approaches are the Direct and Indirect approaches. The Direct approach looks at techniques that attempt to elicit preferences directly by the use of survey and experimental techniques, such as the Contingent Valuation and Contingent Ranking methods. People are asked directly to state or reveal their strength of preference for a proposed change.

In contrast, Indirect approaches are those techniques that seek to elicit preferences from actual, observed market based information. Preferences for the environmental good are revealed indirectly, when an individual purchases a marketed good with which the environmental good is related to in some way. The techniques included here are, Hedonic Price and Wage techniques, the Travel Cost method, Avertive Behaviour and Conventional Market approaches. They are all Indirect because they do not rely on people's direct answers to questions about how much they would be willing to pay (or accept) for an environmental quality change.

2.4.2.1 The Direct Valuation Approach

In the direct approach an attempt is made to elicit preferences by either experiments or questionnaires.

Eliciting Rankings is similar to contingent valuation except that the questioner is content to obtain a ranking of preferences which can later be 'anchored' by the analyst in a real price of something observed in the market. This is known as the *Contingent Ranking Method* (CRM).

Eliciting Values involve asking people directly to state or reveal 'what they are willing to pay for some change in provision of a good or service or to prevent a change' and/or 'what they are willing to accept to forego a change or tolerate the change'. A contingent market encompasses the good itself, the institutional context in which it would be provided, and the way it would be financed. The situation the respondent is asked to value is hypothetical and respondents are assumed to behave in an identical way to that in a real market. Structured questions and various forms of 'bidding game' can be devised involving 'yes/no' answers to questions regarding maximum willingness-to-pay. Econometric techniques are then used on the survey results to find the mean bid values of willingness-to-pay. This is known as the *Contingent Valuation Method* (CVM). However the central problem with the approach is whether the intentions people indicate ex-ante (before the change) will accurately describe their behaviour ex-post (after the change) when people face no penalty or cost associated with a discrepancy between the two.

2.4.2.1.1 Technical Acceptability of CVM

An assessment of the technical acceptability of CVM involves looking at various methodological issues, which we divide into issues of Reliability, Bias and Validity.

A) Reliability

Reliability looks at the degree to which the variance of WTP responses are attributable to random error. The greater is the degree of non-randomness, the less the reliability of the study such that mean WTP answers are of little value. In order to assess reliability, a number of practitioners have advocated the use of replicability tests, i.e. repeating an experiment using different samples to see if there is correlation between the variables collected. Although few such tests have been carried out in practice due to their expense, Heberlein (1986), Loehman and De [1982] and Loomis [1989, 1990] have carried out such testing and found significant correlation between WTP in the test and retest.

B) Bias

The problem of strategic bias has long worried economists. The behaviour necessary for this kind of bias depends on the respondent's perceived payment obligation and his expectation about the provision of a good. Where individuals actually have to pay their reported WTP values then there is the temptation to understate their true preferences in the hope of a free-ride. Or if the price to be charged for the good is not tied to an individual's WTP response, but the provision of the good is, then over reporting of WTP may occur in order to ensure provision.

Hypothetical Bias due to the hypothetical nature of the market in CV studies can render respondents answers meaningless if their declared intentions cannot be taken as accurate guides of their actual behaviour. A survey of experimental tests reveals that by using a WTP format instead of a WTA format, hypothetical bias, which may be a significant problem in WTA studies, can be reduced to an insignificant level. The tests usually compare the hypothetical bids with bids obtained in simulated markets where real money transactions take place. Results from such studies suggest that the divergence between actual and hypothetical WTP is much less than that for WTA, the reason being that respondents are more familiar with payment rather than compensation scenarios (Hanley [1990]).

There is evidence to suggest that people have problems understanding certain kinds of questions that depend on insights into their own feelings or their memory of events or feelings. This kind of problem will be very apparent in environmental issues because these evoke deeply held moral, philosophical, and religious beliefs. One particular problem in this vein much looked at, is that respondents may interpret the hypothetical offers of a specific good or service to be indicative of an offer for a broader set of similar goods and services. This is known as the embedding problem since the value of the good being sought is embedded in the value of the more encompassing set of goods or services reported by the respondent. This problem is indicative of an even broader problem with obtaining accurate answers. For a single individual the total amount they are WTP for improved environmental goods and services may be determined by the composition or components of the total set of environmental projects and policies to be funded. However, this information is unlikely to be obtained from the aggregation of values based on a set of CV studies designed to measure individuals' preferences for narrowly defined environmental goods.

The quality of information given in a hypothetical market scenario almost certainly affects the responses received. A number of writers have argued that information will always affect WTP but that this result applies to all goods be they public or private.

There may be problems in aggregating individual valuation responses. Analysts will often wish to summarise respondents' answers to valuation questions in terms of the mean willingness-to-pay for the good or service, or, develop an aggregate benefit estimate for a community or region. Two types of problems here are sampling errors and insufficient sample size. Sampling errors include a non random sample being selected and used. This may result from non-responses to the questions. Non-responses are more likely to occur for certain types of individuals who are not randomly distributed in the population. If the size of the sample is small, there is a risk that the characteristics of the sample will not be representative of the general population thus resulting in findings which suffer wide confidence intervals. Furthermore, non normal WTP distributions can cause the sample mean to be biased by the major tail of the distribution, necessitating the use of truncated means as an aggregate measure of welfare.

Often, on-site surveys will ignore the non-use values held by non-visitors such that additional random sample off-site surveys will be needed to estimate non-use values. Empirical studies have found total non-use value is significant and can even exceed total use value.

The way interviewers conduct themselves and the interview can influence responses resulting into interviewer and / or respondent bias.

A number of studies have found that WTP varies depending on whether an income tax increase or an entrance fee is used as a payment vehicle (method of payment for the good). To minimise this bias, controversial payment vehicles should be avoided and a method used which is most likely to be used in real life to elicit payment for the good in question.

C) Validity

There are three categories of validity testing used in CVM studies. These are Content, Criterion and Construct validity.

Content Validity looks at whether the WTP measure estimated in a CV study accurately corresponds to the object being looked at (the composition). Such testing cannot be formalised resulting in analysts having to decide in a subjective manner whether a CVM has asked the correct questions appropriately, and if the WTP measure is in fact what respondents would actually pay for a public good if a market existed.

For Criterion Validity, CVM estimates are compared with the 'true' value (the criterion) of the good in question. This is not feasible for many environmental goods (and is why CVM is carried out in the first place). However, experiments comparing hypothetical WTP sums from CVM with 'true' WTP as determined by simulated markets using real money payments have been carried out. These find that in general WTP format CVM studies give valid estimates of true WTP, though this is not the case for WTA.

Construct Validity includes Convergent and theoretical validity. Theoretical validity tests whether the CVM measure conforms to theoretical expectations and convergent validity tests whether the CVM measure is closely correlated with measures of the good found using other valuation techniques.

Theoretical validity tests have centred on examining bid curve functions to see if they conform to theoretical expectations e.g. if elasticities are correctly signed and feasibly sized; tests on the significance of explanatory variables (by looking at simple 't' statistic tests, and the explanatory power of bid functions).

Convergent validity compares CVM measures with revealed preference techniques such as Travel Cost and Hedonic Pricing. However, the methods compared are usually measuring different theoretical constructs e.g., CVM measures use and non-use values whereas Travel Cost only measures use values. Furthermore, CVM provides ex-ante measures of WTP whilst hedonic pricing and travel cost estimates are from ex-post contexts. As such the usefulness of convergent validity testing is not as great as at first thought.

2.4.2.1.2 Conclusion on CVM

It is important to get accurate, reliable answers to CV questions. In a report to the US NOAA committee, Arrow et al [1992] have offered a set of guidelines that they believe CV researches should follow in order to ensure that CV studies provide accurate, reliable information. The best prospects for use of CVM is in attempting to find WTP for an environmental gain and when familiar goods are being looked at such as local recreational amenities. WTP and WTA for environmental losses are more problematic. Finally, it should be remembered that CVM is the only technique with the potential for measurement of existence value.

2.4.2.2 The Indirect Valuation Approach

Indirect approaches are those techniques that seek to elicit preferences from actual, observed market based information. Preferences for the environmental good are revealed indirectly, when an individual purchases a marketed good with which the environmental good is related to in some way. The techniques included here are, Hedonic Price and Wage techniques, the Travel Cost method, Avertive Behaviour, Dose-Response and Replacement Cost techniques. They are all Indirect because they do not rely on people's direct answers to questions about how much they would be willing-to-pay (or accept) for an environmental quality change. The Indirect group of techniques can be divided into two categories. These are surrogate market approaches and conventional market approaches.

2.4.2.2.1 Surrogate Markets

Surrogate market techniques involve looking at markets for private goods and services, which are related to the environmental commodities of concern. The goods or services bought and sold in these surrogate markets will often have as complements (or attributes) and substitutes the environmental commodities in question. Individuals reveal their preferences for both the private marketed good and the environmental good when purchasing the private good. They leave what is called a "behavioral trail" as they make actual decisions that affect their lives. Policy makers therefore sometimes prefer these techniques because they rely on actual choices rather than the hypothetical choices involved in the Direct approaches. Surrogate market approaches include Hedonic techniques and Household Production Function techniques.

(a) Household Production Functions

The Household Production Function (HPF) approach places values on environmental resources by specifying some familiar structural relations (restrictions) between the environmental services of interest and other private goods. The approach argues that the environmental resource and private goods are demanded as intermediaries in a household's production process, together with time, to produce service flows. The approach describes how goods and services are used and so enables us to see how the environment affects the service flows. In a household production function, the environment enters the individual's behavioural/preference function through the restrictions of perfect substitutability and weak complementarity. The values of the environmental resource are found by looking at changes in the expenditure on goods that are substitutes or complements to the environmental resource.

Perfect substitutability is the basis of the *Averting Behaviour technique*, which looks at how averting inputs substitute for changes in the environmental good of concern. To undertake such estimation, data on the environmental change and its associated substitution effects is required. In order to apply this approach the averting behaviour must be between two perfect substitutes otherwise an underestimation of the benefits of the environmental good will occur.

Averting behaviours are never likely to involve perfect substitutes and even when they do, bias in the estimation of benefits can still occur. For example, if there is an increase in environmental quality, the benefit of this change is given by the reduction in spending on the substitute market good required to keep the individual on their original level of welfare. However, when the quality change takes place the individual will not reduce spending so as to stay on the original welfare level. There will have been an income effect as well as a substitution effect between environmental quality and the substitute good. Expenditure will therefore be reallocated among all goods with a positive income elasticity of demand and so the reduction in spending on the substitute for environmental quality will not capture all of the benefits of the increase in quality.

Further problems with the approach include the fact that individuals may undertake more than one form of averting behaviour to any one environmental change, and, that the averting behaviour may prevent the adverse effects of reducing the environmental good but may also have other beneficial effects which are not considered explicitly, e.g., sound insulation may also reduce heat loss from a home. Furthermore, averting behaviour is often not a continuous decision but rather a discrete one. In this case the technique will again give an underestimate of benefits unless discrete choice models for averting behaviour are used.

So, simple avertive behaviour models although having relatively modest data requirements can give incorrect estimates if they fail to incorporate the technical and behavioural alternatives to individuals responses to quality changes.

Although the technique has rarely been used, it is a potentially important source of valuation estimates since it gives theoretically correct estimates which are gained from actual expenditures and thus have high criterion validity.

Weak complementarity is the basis on which the *Travel Cost approach* works. The approach has been widely used to measure the demand and benefits of recreation site facilities and characteristics. Travel is used to infer the demand for recreation by virtue of the fact that it is a weak complement to recreation, i.e. when the quality of the recreation site changes, we look at how expenditures on the marketable complement, travel, change. The Travel Cost method estimates the demand function for recreational facilities and finds how visitation to a site changes -- how the demand curve will shift -- if an environmental resource in the area changes.

Information on money and time spent by people in getting to a site is used to estimate willingness-to-pay for a site's facilities or characteristics. The problem here is that recreation sites charge a zero or negligible price which means that it is not possible to estimate demand in the usual way. However, by looking at how different people respond to differences in money travel cost (including transport, admission and the value of time, etc.) we can infer how they respond to changes in entry price, since one acts as a surrogate price for the other and variation in these prices results in variation in consumption.

The Travel Cost demand function is interpreted as the derived demand for a site's services and depends on the ability of a site to provide the recreation activity. Only Use Values are therefore considered, with Existence and Option values being ignored. Since the recreation activity takes place at specific sites that have observable characteristics and measurable travel costs then recreational service flows are described as site specific. The approach can therefore provide us with estimates of the value of the site itself and, by observing how visitation rates to a site change as the environmental quality of the site changes, provide us with values for environmental quality itself.

The travel cost approach makes the central assumption that visit costs can be taken as an indication of recreational value. However, if individuals have changed their place of residency so as to be close to a site then the price of a trip becomes endogenous and the central assumption is violated. The estimated demand curve will lie below the true demand curve and so consumer surplus will be underestimated. A similar challenge to the central assumption also arises in cases where the on-site time is not the only objective of the trip, e.g. where multi-purpose trips are made.

The data requirements of the approach are fairly substantial. A survey must be carried out to establish the number of visitors to a site, their place of origin, socioeconomic characteristics, the duration of the journey and time spent at the site, direct travel expenses, values placed on time by the respondent, purpose of the visit other than visiting the site (multi-purpose visits raise problems for the technique), and a whole range of environmental quality attributes for the site and substitute sites. All of this data collection is expensive and time consuming to carry out.

The Travel Cost approach is an important method of evaluating the demand for recreational facilities. The techniques used have improved considerably since the earliest studies were carried out both from an empirical and theoretical point of view. There are reservations as to its use, particularly concerning the large amounts of data required which is expensive to collect and process. Furthermore difficulties remain with the estimation and data analysis techniques and so the method is likely to work best when applied to the valuation of a single site, its characteristics and those of other sites remaining constant.

(b) Hedonic Pricing

The Hedonic approach is in fact similar to the Household Production Function approach since both require the weak complementarity assumption. The Hedonic approach differs in that it operates through private good price changes rather than private good quantity changes.

The Hedonic Pricing approach looks at markets in some private good for which the environmental good of concern is again a weak complement (or attribute), in order to infer individuals' preferences for environmental quality. An example of this is the property market, in which one of the attributes of housing influencing an individual's decision to buy or sell, is the level of environmental quality, e.g. air pollution in the surrounding neighbourhood. Given that different locations of property will have different levels of environmental attributes and that these attributes affect the stream of benefits from the property, then the variation in attributes will result in differences in property values (since property values are related to the stream of benefits). The Hedonic price approach looks for any systematic differences in property values between locations and tries to separate out the effect of environmental quality on these values. Consequently, the implicit prices found for environmental quality must be related to consumers' tastes and preferences in order to find the attributes demand function (since the implicit price of the attributes reflect the forces of supply and demand).

To find the demand function relating the quantity of the environmental attribute to individuals WTP it is necessary to first define the market commodity (e.g. housing) and the environmental attribute of the market commodity (e.g. air quality). A functional relationship is then specified between the market price and all the relevant attributes of the market commodity. This is called a Hedonic Price function. The hedonic price function is then estimated using multiple regression techniques from data on property values and the associated attributes of the property. We are thus able to find the hedonic price function coefficient on the attribute of interest (air quality) and this coefficient is known as the marginal implicit price of the attribute. It gives the additional amount of money that must be paid by an individual to buy an identical market good but with a higher level of the environmental attribute.

Data from a wide range of different properties is required with information on all features that influence the properties' value such as structural characteristics (number of rooms, size, etc), neighbourhood characteristics ('prestige', closeness to business and amenity areas, etc), and environmental characteristics (air quality, noise levels, etc), as on the property values themselves. In practice, sufficient data of the variety to enable reliable estimation may be difficult to come by, especially in areas and countries containing a large amount of public sector housing. The data on property values should come from actual market data but since only a small percentage of the total owner-occupied housing stock may be sold per year, then collection of a large enough sample of data may be difficult. Care must be taken to account for the effects of property taxation on property values otherwise their use will result in an overestimation of benefits. A further problem is that property prices may be influenced by expected future changes in the property and so the characteristics at the time of a sale may not adequately explain the selling price. Rental price data could be used to overcome this and is in any case the theoretically correct measure to use. However the rental market may be even less perfect than the property market in some countries. As an alternative Real Estate agent valuations could be used.

A major problem with hedonic price studies is that of multicollinearity -- the fact that many of the explanatory variables will be related to one another. The whole approach relies on the assumptions of a fixed supply of housing and a freely functioning and efficient property market. Individuals have perfect information and mobility such that they can buy the exact property and associated characteristics that they desire and so reveal their demand for environmental quality.
Another problem with the approach is that hedonic price includes the consumer valuation of not only present day benefits but also the stream of expected future (discounted) benefits from environmental quality, and as such will tend to overstate WTP.

Finally, the possibility that mitigating or averting behaviour by individuals may take place to avoid the effects of pollution, such as installing pollution filters, needs to be looked at (see the earlier section on averting behaviour). If this behaviour is unrelated to the characteristics of the property then it will reduce the value of the property and need not be measured separately. If changes do occur to the property then the value of the property will increase and so such changes need to be included in the hedonic equation.

To conclude, the hedonic approach is founded upon a sound theoretical base and is capable of producing valid estimates of benefits so long as individuals perceive environmental changes.

The weak complementarity and perfect substitutability assumptions on which the hedonic and household production function approaches are based are the reason why only use values can be measured by either of the two approaches -- this is because values that do not entail direct consumption cannot be estimated by looking at complements or substitutes.

A further problem with surrogate techniques is that they cannot estimate the value of a new good or service, or of a change in environmental quality outside of current experience, since no situations exist where people have been offered the new level of environmental quality and have revealed their preferences for it.

2.4.2.2.2 Conventional Market Approaches

Conventional market approaches are used in situations where the output of a good or service is measurable. These approaches use market prices (which may be adjusted by shadow pricing if market prices do not accurately reflect scarcity), or revealed/inferred prices (if no markets exist) to value environmental 'damage'. Where the damage shows up in changes in the quantity or price of marketed inputs or outputs, the value of the change can be measured by changes in the total 'consumers plus producers surplus'.

Two techniques may be distinguished: the dose-response technique and the replacement cost approach.

(a) The Dose-Response Technique

The dose-response technique aims to establish a relationship between environmental damage (Response) and some cause of the damage such as pollution (Dose), such that a given level of pollution is associated with a change in output which is then valued at market, revealed/inferred, or shadow prices.

Where individuals are unaware of the impact on utility of a change in environmental quality then direct WTP/WTA is an inappropriate measure and so dose-response procedures which do not rely on individuals preferences can be used.
The technique is used extensively where dose-response relationships between some cause of damage such as pollution, and output/impacts are known. For example, it has been used to look at the effect of pollution on health, physical depreciation of material assets such as metal and buildings, aquatic ecosystems, vegetation and soil erosion. The approach is mainly applicable to environmental changes that have impacts on marketable goods and so it is unsuitable for valuing non-use benefits.

Damage actually done is found using a 'dose-response function' which relates physical/biological changes in the ambient environment to the level of the cause of the change. The dose-response function is then multiplied by the unit 'price' or value per unit of physical damage to give a 'monetary damage function'.

The Dose-Response approach in its most basic form looks at environmental resources which lead to a marginal change in the output of a good sold on a competitive market and values the impact directly in terms of output changes valued at market prices.

In order to be of use in a policy making context, marginal damage valuations are needed. Dose-response relationships are likely to be non-linear with damage rising proportionately more as pollution increases. Even if physical damage increases proportionately, monetary valuation per unit damage may still be non-linear. Valuations based on average physical damage and average valuations will underestimate damage values at high pollution levels and overestimate them at low levels. Damages from each incremental unit of ambient pollution concentration need to be found and linked to changes in pollutant emissions such that we have marginal damages per unit of emissions.

Usually the current market clearing price is used as the unit value of monetary damage. Since dose-response functions are defined in per unit terms then knowledge of the actual quantity of material exposed to pollution is required. Allowance must also be made for distortions in the price level due to market interventions and imperfections.

Non-marketed goods require the use of values from close marketed substitutes or, for subsistence production "border prices" can be used. Revealed/stated preference study estimates are used when other values are not available.

To conclude, the Dose-Response approach is a technique that can be used where the physical and ecological relationships between pollution and output or impact are known. The approach cannot estimate non-use values. The approach is theoretically sound, with any uncertainty residing mainly in the errors of the dose-response relationship, e.g., are there threshold levels before damage occurs, or discontinuities in the dose damage function. It is necessary to allow for the fact that the behaviour of individuals may change in response to changes in the environment. If this is not possible, but the direction of any bias resulting is known then this should be stated.

The approach may be costly to undertake if large databases need to be manipulated in order to establish the relationships. If the dose-response functions already exist though, the method can be very inexpensive, with low time demands, and yet it can provide reasonable first approximations to the true economic value measures.

(b) The Replacement Cost Technique

This technique looks at the cost of replacing or restoring a damaged asset to its original state and uses this cost as a measure of the benefit of restoration. The approach is widely used because it is easy to find estimates of such costs.

The approach is correct where it is possible to argue that the remedial work must take place because of some other constraint such as a water quality standard. Under such a situation the costs of achieving that standard are a proxy for the benefits of reaching the standard, since society can be assumed as having sanctioned the cost by setting the standard. However, if the remedial cost is a measure of damage then the cost-benefit ratio of undertaking the remedial work will always be unitary. That is to say remedial costs are being used to measure remedial benefits. To say that the remedial work must be done implies that benefits exceed costs. Costs are then a lower bound of the true value of benefits.

Information on replacement costs can be obtained from direct observation of actual spending on restoring damaged assets or from professional estimates of what it costs to restore the asset. It is assumed that the asset can be fully restored back to its original state. However, some damage may not be fully perceived, or may arise in the long term, or may not be fully restorable. Benefits will therefore be underestimated. Another problem here is that restoration of damaged assets may have secondary benefits in addition to the benefits of restoration such that replacement costs will underestimate total benefits.

2.4.2.3 Choice of Valuation Technique

All of the valuation techniques outlined have strengths and weaknesses as we have seen, and the decision on which valuation technique to use for a particular application requires experience and judgement on the part of an analyst. There are, however, some general points to consider when making a choice.

First, the technique should be technically acceptable with respect to its validity and reliability. Measures obtained from the technique should be consistent and accurate. Methods suffering random errors require reliability checks to judge their predictive capacity. Methods suffering non-random error contain bias problems, thereby reducing reliability and the validity of the measurement results. Validity cannot be assessed solely on the basis of technique methodology but must be considered alongside practical predictive ability.

Reliability problems will occur if the sample size of the data is too small or a survey design is deficient. Reliability is closely related to bias which can vary depending on the good being looked at.

The Hedonic Pricing and Travel Cost approaches have weak validity since they assume the underlying theory is correct in order to generate results, whereas CVM can build in tests for reliability and validity. A more psychological approach can to be taken with CVM, with direct psychometric testing of the validity and reliability.

Second, the technique should be institutionally acceptable such that it fits into current decision making processes. There are differing views as to the acceptability of monetizing the environment.

Third, it is important to consider the needs of the user(s) of valuation studies who may prefer the use of one valuation technique over another. For example, estimates obtained from travel cost or hedonic property value models may be considered too theoretical or too complex. On the other hand it may be felt that contingent valuation estimates are too subjective and unreliable to support policy debate and discussion. The analyst carrying out policy work must be sensitive to such concerns. The technique should also be user friendly in terms of how easy or difficult it is to use in practice.

Fourthly, the financial cost of the study needs to be weighed against the value of the information gained.

Finally, it should be remembered that it would often be possible to use more than one valuation technique and compare the results. The estimates of value obtained from all the methods described will be somewhat uncertain. If the analyst has multiple estimates, then they will have greater confidence in the magnitude of the value of the proposed change. Several of the valuation techniques typically use data from a household survey (e.g., contingent valuation, travel cost model, and hedonic property value model). When the implementation of a valuation technique requires that primary data be collected with a household survey, it is often possible to design the survey to obtain the data necessary to undertake more than one valuation method.

2.5.0 Valuing Genetic Resources

2.5.1 The nature of genetic resources

The very nature of genetic resources complicates valuation, a necessary step in establishing the genetic resource market. According to CBD, genetic resources are any materials of plant, animal, microbial, or other origin that contains functional units of heredity of actual or potential value. The material and geographic aspects of genetic resources pose an extraordinary challenge to national and international policymakers because most living organisms reproduce and disperse naturally, irrespective of the restrictive measures that policymakers wish to lay on them. This biological fact is compounded by the elusive nature of information, even when derived from biological material, is intangible and therefore requires a special property regime.

The overall value of biological diversity- and the genetic resources it constitutes- rests on the total impact of the marginal conversion of land-use to specialized biological resources. The resulting value can be divided into static (material, tangible) and dynamic (information-based, intangible) components. The static value of genetic resources is the sum of its conversion value (often considered negative at any given time, since it is instantly more profitable to convert land to, for instance intensive monocropping) and the value of retention of the wider range of assets within the biological system (Swanson, 1995). These " assets" or "services" include but not limited to, the role of biodiversity as carbon sinks, pest control, and its aesthetic and recreational importance (Roughgarden, 1995).

The dynamic value of genetic resources derives from its option value- the value of certain characteristics known in plant and animal varieties which may prove useful in facing new environmental and health challenges- and the exploration value inherent in the possibility of finding a useful natural compound.

Despite the spirit of patent laws requiring innovation, non-obviousness and usefulness, genetic resources today may be considered closer to human inventions than to natural discoveries in legal terms. Nonetheless, the difficulties in characterizing and assessing the value of genetic resources are pervasive.

2.5.2 Genetic resource ownership and tenure

Assessments of genetic resource ownership are extremely complicated. Although it is relatively easy to determine ownership of a cow, or the production from a sorghum field, the equivalent operation for fungi, frogs, or previously undescribed plants is significantly more difficult. Part of the problem resides in the fact that knowledge of behavior, lifecycle, yield, feeding habits, or distribution remains scant for most species, except for a few domesticated living organisms.

The rights of ownership and tenure of natural resources have always been subject to dispute, with individuals, peoples, and nations willing to face wars if such an extreme measure seemed necessary. Genetic resources are not exception, with further complications stemming from the lack of knowledge regarding living organisms, the widespread occurrence of certain species and processes, and the different levels of geographic jurisdiction over areas of endemism. Since property delimitation and evaluation of tenure are pivotal to the recognition and enforcement of property rights, the effective institutionalization of rights to genetic resources is an extraordinarily challenging task for policymakers.

The CBD recognizes the sovereign rights of individual countries, with the national government in charge of assigning property rights over the resources (Glowka, 1998). Tenure and ownership systems, however, are not uniform across all countries, nor are they clearly defined in any given country. For example, legal systems in modern states can be divided between those subscribed to English Common law and those founded on Roman law. The first system views natural resources as private property, and the state has little participation in regulating access, whereas the latter system grants property to the state, holding natural resources as national patrimony (Ruiz-Muller, 1998). Based on this legislative heritage and each country's own cultural traditions, biodiversity-rich countries exhibit a mixture of ownership arrangements that range from traditional common tenure to state-enforced private rights to land and natural resources, including biodiversity.

In general, the ownership system applicable to property rights in developed countries is the product of historical patterns of industrialization, urbanization, and, to a certain degree, centralization. These systems are founded on individualism and optimum profit (Chichilnisky, 1998). In developing countries, most traditional communities have continued to apply their own tenure system for biological resources, while the state enforces private and public property rights on goods and mild Intellectual Property Rights

(IPR) laws on industry and commerce. Many traditional tenure systems regarding genetic resources are grounded on collective ownership or heritage and, sometimes, religious and mystical considerations, particularly in the case of medicinal plants.

Biological scientists argue that almost all genetic resources are potentially valuable and hence should be conserved (e.g., Wilson, 1988). It is assumed that all genetic material has potential value, because the future technologies and environmental conditions are not yet known (McNeely et al., 1990). Consequently, the future value of existing genetic resources cannot be determined at present. Additionally, there are arguments defining the value of genetic resources purely from an environmental-ethical point of view (e.g., Busch et al., 1989; Oldfield, 1989; Shiva, 1991). On the other hand, based on anthropocentric aims, genetic resources are only considered to be valued to the extent that they serve (or may in future serve) the human race.

2.5.3 A Conceptual overview of Genetic Resource Value

There are several approaches for valuing genetic resources. Most methods treat genetic resources as non-marketed goods and services, utilizing either the surrogate or constructed markets, thereby estimating people's willingness to pay. Depending on the different methods used, economists are estimating different values for different parts of "genetic resources".

In addition to the difficulties in assessing the value of GCI, the value of genetic resources is only partially reflected in the market price. Besides the fact that the market is only able to capture a fraction of the overall value of genetic resources (for instance, conventional market mechanisms are not able to incorporate intergenerational aspects and the irreversibility loss of genetic resources) the markets for genetic resources are incomplete or even missing. For example, often no price is charged for the utilisation of genetic resources through breeders. In addition, the value of GCI can seldom be determined a priori but only observed a posteriori, i.e., as a result of their success on the market. Hence, the internalisation of benefits as royalties (a posteriori) for individuals is not possible because of the intergenerative structure of benefits. The internalisation of benefits, as payment on account (a priori), will seldom reflect the true use value of specific GCI.

The total economic value of genetic resources has to be defined by breaking down the overall value into its various parts. The components of the total economic value are derived from the use value, which is divided into the direct and indirect use value and the option value. Further components are the bequest value and the existence value summarized in the non-use value. Table 2.1 shows the desegregated values of genetic resources. One immediately obtains an idea of the anticipated benefits derived from the different values and of the decreasing quantifiability and valuability from left to right in the range of value categories depicted in Table 2.1.

On the one hand, the direct use value arises from the use of resources in production and consumption of genetic resources by the pharmaceutical industry and plant breeders, farmers, food processors, and consumers. On the other hand, it arises from non-consumptive uses, e.g., through recreation, tourism, etc. The indirect use value reflects the value of genetic resources, though not directly consumed, are necessary to the production of resources, which have direct use value. These are the ecological functions of genetic resources (e.g., prevention of soil erosion, regeneration of air and water quality). The final use value is the option value, permitting one to make use of the resources in the future by preserving the resources and avoiding irreversible losses of genetic resources (Weisbrod, 1964; Fisher et al., 1983). The existence value and the bequest value are the two components of the non-use value. The latter is the value of keeping a resource intact for one's heirs, whereas the former is the value conferred by assuring the survival of a resource for its own sake or for some ethical or other reason. (Krutilla, 1967; Brown, 1990; Pearce et al., 1990; Randall, 1991; Turner, 1993; Turner et al., 1994). The importance of the existence value will depend significantly on the relevant genetic resources. The existence value of a wild animal species (e.g., elephant) will be much higher for most of the society than that of some varieties of agriculturally relevant crops or even some micro-organisms. The latter, however, reflect a significant higher use-value due to their use in the R&D of pharmaceuticals or seeds.

Contemporary understanding of the benefits of genetic diversity and the value of the benefits that genetic resources provide is not so well appreciated. This is due to two main reasons: (a) that it is the least-known level of biodiversity and consequently our understanding of the resources is poorer than for other manifestations of biodiversity; and (b) estimating the value of the benefits of genetic diversity poses many extra methodological difficulties compared with undertaking a similar exercise for other aspects of biodiversity. This arises because the principal direct economic value of genetic diversity is the information that it represents. Measuring this benefit, as with other intangible benefits, has always been problematic because what is required is not a calculation of an easily measured consumptive process, but the value of the information that the resource brings to the production process. As this will often be only one of many sources of information required to develop the process, and often not even the most important source, assessing the proportion attributable to the natural genetic resources is not straightforward. Thus, what is being measured in this process is not the market for herbal remedies, but the value of the contribution that a natural biochemical makes to developing a new drug or a new crop variety. As there is no well-established methodology for estimating this type of contribution, it is largely dependent upon the subjective values of those making the assessment. Work on estimating other benefits of the value of genetic diversity (such as its indirect, option and existence values) is almost non-existent.

2.5.4 A Critique of Valuation Methodologies used in estimating the Value of Biodiversity

A number of techniques, which have been developed for assessing the value of public goods in general, have been utilized for the valuation of natural resources as well (Barbier et al., 1994). The valuation techniques can be differentiated according to the type of market they rely on and depending on the kind of behaviour of the individuals concerned. Where possible, the asset or parts thereof are valued based on the average return of production as well as on some specific adjustments. These calculations are based on actual market prices and factual or potential behaviour of the involved actors.

This technique is used quite frequently for valuing the avoidance of pollution and of biodiversity in general, especially through national parks by the travel cost method. The majority of use values of natural resources can be estimated by the techniques based on conventional or surrogate markets whereas the non-use values mainly have to be estimated by utilising constructed markets. Underlying all the techniques corresponding to surrogate and constructed markets is the willingness to pay of individuals for the environmental good (Braden and Kolstad, 1991).

Although there has been some work on valuation, a few examples exist for estimations of the productivity contributions of wild relatives of crops and for rice by quantifying the breeding value using hedonic trait value estimates (Evenson, 1994; Evenson, 1996; Gollin, 1996). These figures have to be, however, sensitively interpreted, because they do not give the isolated value of the genetic material used, but rather the aggregate value of both the genetic resources, as well as the contribution through research inputs as capital, labour and technology (NRC, 1993). It requires proprietary information and costly studies to separate the value of the genetic resources from the value-added by R&D. Other estimates based on a simple search model show that genetic resources are not scarce, and therefore not of much economic value (e.g., Simpson et al., 1996). These examples show that an economic analysis of the value of genetic resources is still in its infancy.

Valuation and methodologies for evaluating the benefits of biological diversity at the species and ecosystem level are rapidly evolving. A recent and relatively comprehensive assessment of this area is provided in the Global Biodiversity Assessment (Perrings 1995).

In current policymaking and academic discussions, the methodologies used to estimate the value of natural and biological resources (especially genetic resources) and the accuracy of such estimates are much debated. Due to the inherent difficulties of quantifying the value of natural goods and services, different approaches yield a wide range of conclusions. Interpreting the findings of various studies consistently and applying the results to form successful policy will remain a challenge for decisionmakers.

2.5.5 Conclusion

A literature review highlighted the need to adopt a consistent classification framework for economic benefits. The one adopted for this research is consistent with a broad literature of environmental economics and terrestrial biodiversity valuation, summarized by Pearce and Moran (1994), among many others. Total Economic Value (TEV) is taken as the sum of `use' and `non-use' values. Use Values comprise the sum of: (i) Direct Uses such as fisheries, recreation, and building supplies; (ii) Indirect Uses or Functions such as storm protection; and, (iii) Option Values that preserve options for future use. Non-use Values include Bequest Values (the value associated with passing on natural assets `intact') and

Existence Values associated with simply knowing that the resource exists. It should be noted that, although this framework strictly shows that the different values are additive, the actual methods that are used to estimate separate values may not always be additive. Contingent valuation surveys, for example, may capture a combination of direct use and non-use benefits, depending on the wording of questions. Analysts must therefore be familiar with the valuation methods being employed to ensure that double counting does not arise.

The economic literature can be characterized by two schools of thought. The first school of thought demonstrates that either on a theoretical or empirical basis, global biodiversity valuation should not or can not be conducted in any meaningful manner. Perrings (1994), for example, explores the idea that many philosophical arguments exist for treating biodiversity conservation as a constraint to economic development, and that valuation of such biodiversity simply implies that trade-offs are possible and potentially desirable. Spash and Hanley (1995) draw attention to the methodological difficulty of valuation where lexicographic preferences exist; and Ruitenbeek (1990) argues that all neoclassical approaches of estimating global biodiversity values relying on partial equilibrium techniques are incapable of providing a valid estimate because of 'scale' considerations. Tacconi and Bennett (1995) argue that, from an intergenerational perspective, biodiversity values are effectively infinitely large and that any practical analysis should therefore focus entirely on finding cost-effective mechanisms for conservation.

A second school of thought either explicitly or implicitly accepts that some form of valuation is desirable or possible, and many methodologies have been developed to attempt to isolate these values (see Aylward, et al., 1993, for a review). To date, all methodical attempts at estimating biodiversity value have focused on terrestrial biodiversity (e.g., Beese, 1996; Gaston, 1996; Pearce and Moran, 1994; Loomis and White, 1996; and, Kohn, 1997), and valuations have generally covered a very large range of estimates.

Given the increasing preference for market-based policies around the world, integrating the conservation and sustainable use of biological diversity in relevant sectorial or cross-sectorial plans, programmes and policies will rely significantly on being able to assign an economic value to all aspects of biological diversity, including genetic resources.

CHAPTER III: SELECTED CASE STUDIES AND ANALYSIS

3.1 Introduction

The previous chapter provides an overall assessment framework for the economic valuation of biodiversity. However, to critically examine economic valuation methodologies, it is instructive to explore a few selected case study examples. This is the purpose of this chapter. The studies selected are intended to present a summary of practical economic valuation studies conducted from a wide range of geographical regions.

3.2.0 Opportunity cost approach and contingent valuation: Forest functions in Madagascar.

Kramer, R.A., N. Sharma, P. Shyamsundar, and M. Munasinghe. Cost and compensation issues in protecting tropical rainforests: case study of Madagascar, Environment Department working paper, World Bank, Washington DC, 1994.

3.2.1 Introduction

Tropical countries in Africa are putting greater emphasis on management and protection of intact rainforests. Preservation of tropical rainforests has significant social, economic and environmental impacts. Protecting forests gives rise to benefits in environmental impacts. Protecting forests gives rise to benefits in terms of conservation of biodioversity and maintenance of environmental services, but there are also negative impacts borne by people living adjacent to protected areas who depend on these forests for their livelihoods. Often traditional use rights to the forest are lost when large areas of tropical rainforests are protected or converted to other uses.

Development projects have often failed to take into account the opportunity costs of people with traditional rights to forests where large forest areas are protected or converted to other land use activities. The failure to adequately compensate or involve people in the establishment and management of protected areas has resulted in poor performance of many projects dealing with reserves and natural parks. In many instances, these parks and reserve areas are vulnerable to open access problems from local populations.

This study analyses the economic and social impacts of establishing the Mantadia National Park in Madagascar on village households living adjacent to tropical rainforests in the Andasibe region. Two methods are used to estimate the economic impacts on the villagers: (1) Opportunity cost analysis based on household cash flow models constructed from a socioeconomic survey; and (2) contingent valuation analysis based on direct questioning of villagers about required levels of compensation.

The Mantadia National Park does not have any human settlements within its boundaries, but has villages in close proximity, mainly in the south, east and northeast. These villagers are dependent on the forests within the park and immediately around it for forest products and for agriculture. The primary source of livelihood in these areas is shifting cultivation, a major cause of deforestation in the park area. Villagers in this area are also dependent on the forest for a number of other reasons. Fuel wood is collected from the forests on a regular basis, a wide variety of fish and animals are foraged for consumption and a number of different types of grass are harvested and used for assorted purposes. Forest plants and herbs also serve as source of medicine.

3.2.2 Data collection and field procedures.

In order to assess the extent of the dependence of villagers on the forests, a socioeconomic survey was conducted of 351 households living near the park. The survey included a series of questions on economic activities related to use of agricultural land, the forest and household labour. An additional component of the survey was a contingent valuation exercise to assess villagers' willingness-to-accept compensation for loss of access to the park.

This survey was accomplished with the assistance of a local NGO well-versed in rural survey techniques. The household survey was refined based on focus group interviews, conversations with various people who were well acquainted with the area, and a pre-test which covered about 25 households. In addition, a shorter questionnaire was administered to village leaders to obtain information on village history, agriculture and land use practices. To increase the villagers' willingness to participate in the survey, a health team of doctors and nurses was organized to accompany the survey team. The health team provided basic medical consultations and medicines to the villagers who have very little access to health services.

To estimate the opportunity cost to villagers of establishing the Mantadia National Park, cash flow analysis was used. Income from agricultural and forestry activities was estimated for three different groups of villages. The villages were grouped to reflect similar socioeconomic characteristics. Then, depending on the extent to which land in the park had been used by villagers for gathering forest products and practising shifting agriculture (based on analysis of aerial photographs of the park), estimates were made of the income losses associated with the loss of access to park land. Each of the three cash flow models measured the economic benefits from the forests within the park to the locals if they continued to have access to the park. (This is the "without park" scenario). The regulations under which the park has been formulated indicate that the villagers will not be allowed to used the area within the park for shifting cultivation or forest product harvesting (the "with park" scenario). The cash flows, therefore, estimate the value of land to the average household. Monte Carlo simulation was used to examine the effects of fluctuations in key variables on the cash flows.

The second valuation method used in this study was The Contingent Valuation Method (CVM). The CVM questions used a willingness-to- accept format. The pre-test conducted suggested that while property rights over forested land are held by the state, the people in this region have been using forest resources for a long time, and they perceive that they have traditional rights to the land. Willingness-to- accept seemed not only the most appropriate format to use, but also the only way to obtain meaningful responses.

Because several of the villages surveyed had limited involvement in the cash economy, the numeraire used in the survey to obtain WTA bids was rice. Rice is the main crop in this region and its value is well understood. Furthermore, some amount of rice is also sold or bartered and transactions of rice are thus known and understood by the local people. The unit of measure used was a "vata" which is a locally used unit for rice transactions, equaling 30 kilograms of rice.

Prior to posing the contingent valuation question, the respondents were asked a series questions prompting them to begin thinking about the benefits drawn from the park. These questions probed perceptions on different aspects related to the forests like flooding, soil erosion, ancestral traditions, wildlife as destroyers of crops, availability of primary forests in the future etc.

Respondents were also asked if they knew about the park and about their perceptions on the use of buffer zones as alternatives to the forests in the park.

The contingent valuation question used was: -

Suppose you are asked to use only the buffer zone set aside for collecting forest products and for growing crops and are asked not to use the rest of the forests any more. Suppose in order to make up for asking you not to use the forests in the park, you are given _ vata of rice every year from now on. Would this make you as content as before when you could use the forest in the national park? Respondents were randomly assigned to seven groups, corresponding to different amounts of rice used as the offered bid levels.

3.2.3 Results of the analysis.

The household survey covered a total of 17 villages lying to the east and south of the Mantadia region. The total population covered by the household survey was 1,598, indicating that the average household size in this region is 4.6 persons. Most of the villages do not have access to any medical facilities, running tap water or electricity.

The village children in general suffer from malnourishment. Malaria, chest congestion – related illnesses, and venereal diseases are other significant health problems affecting this population. In general, most of the villages surveyed either had or were within 4-5 kilometres from primary school facilities. However, the survey indicated the average number of years of education per person to be only 2.4 years.

Rice production is the primary economic activity in the area. The average household produces 487 kgs of paddy rice per year worth about US $ 128. Most households also engage in shifting cultivation. Eighty percent of the households surveyed said that they would add to existing land for cultivation. Other crops grown are maize, beans, manioc, sweet potato, taro, sugarcane, ginger, banana and coffee. Based on the data collected on agricultural and forestry inputs and outputs, the cash flow models were used to estimate the opportunity costs borne by the villages as a result of lost access to the forests in the park. Averaging over the results obtained from the three cash flow models, the mean value of losses was $91 per household per year (table 1). Aggregating over all households living in the vicinity of the park and using a 10 per cent discount rate and twenty-year time horizon, the net present value of the opportunity costs was estimated to be $566,000. Table.

3.2.4 Summary of economic losses to local villagers from establishment of Mantadia National Park.

Present	Annual mean value per household	Aggregate net
Opportunity cost	$91	$566,000
Contingent	$108	$673,000

The contingent valuation responses were analyzed with an econometric model. The discrete choice responses were used to estimate a bid function in a logistic regression framework. The estimated bid model revealed that a number of socioeconomic variables were systematically related to the probability of accepting offered bids. The bid level itself was a positive and significant explainer of responses. The model correctly predicted 86 percent of the responses, clearly indicating that the elicited responses were non-random. From the estimated bid function, a mean bid was calculated. The responses to the contingent valuation questions indicate that on average, a compensation of rice equivalent in value of $108 per year per household would make households as well off with the park as without (table 1). Aggregating over the population in the park area, this implies a necessary one time compensation of approximately $673,000 assuming a 10 per cent discount rate and twenty year time horizon.

3.2.5 Discussion.

The Mantadia National Park has been established with the intention of preserving Madagascar's unique biological heritage. While the benefits of conserving the fauna and flora and the biological diversity within the park are large, some very significant opportunity costs must be considered, as a necessary condition, to avoid open access problems that will threaten the existence of the park in the long run. The park will negatively affect approximately 3,400 people in three sets of villages. The results suggest that an annual compensation of approximately $100 per household would be required. Such compensation could be made in the form of education, health facilities, and alternative income earning enterprises in the buffer zone, or other development activities. These compensation costs appear to be a significant part of the true cost of implementing protected area projects and should be built into project design at an early stage. Without adequate compensation and active cooperation of local residents, natural resource management projects are more likely to fail.

The cash flow approach used in this study is relatively simple, but data-intensive form of analysis. It is a powerful tool for understanding the inter-relationship among microeconomic factors relating to use and management of parks. In this study, contingent valuation was also used to estimate the welfare change perceived by local residents as a result of loss of access of access to lands currently within the Mantadia national park. The analysis indicates that CVM, rigorously applied, can be effectively used in the developing country context. The econometric analysis undertaken indicates a systematic association between various socio-economic variables of interest and the expressed WTA compensation. Also, the opportunity cost (or market based) approach and the CV method provided remarkably comparable estimates of costs borne by villages. All this is encouraging evidence to support the use of CV in such a context, but further research is required to improve its widespread applicability. Several lessons can be drawn from this study. This research has involved a survey of village households, collection of data on various quantities and prices and rigorous quantitative analysis. Research of this kind is time-intensive. It is apparent that there is a strong need for a significant amount of pre-survey work to draft a useful survey instrument. There is a need for focus groups and a formal pre-test to sharpen the wording of the questions so that the desired information can be collected. For example, it was found that units of measure for forest products varied between villages only a few kilometres apart. There is a need for involving local sociologists and cultural anthropologists (as was done in this study) who can ensure that the questions are posed approximately for the local cultural context, and to advise researchers on the appropriate protocol for approaching local village leaders to ensure their cooperation. In this instance, it was found advantageous to provide an incentive for survey participation by arranging to have a health team accompany the interviewers of course, careful translation into local languages is also a necessary step, as is thorough training of interviewers. The study team worked with an experienced rural survey group, but found that extensive training was still necessary. This was in part due to the fact that they were unfamiliar with the contingent valuation method. Despite the considerable effort required to collect the data gathered for this village study, this information is critically important for implementing conservation projects, and can be collected when baseline information about residents within or around conservation areas is gathered.

3.3 Travel cost method: valuation ecotourism in a Tropical rainforest reserve.

Tobias, D. and R. Mendelsohn (1991), Valuing Ecotourism in Tropical Rainforest Reserve. Ambio, 2:2, 91-93.

3.3.1 Introduction

In many countries forest loss often derives from the perceived value of the forests resources relative to alternative land uses, particularly agriculture. Prescriptions for forest conservation therefore stress the need to recognize the resource's total economic value. In other words, forests are worth more than their timber. A comparison of relative returns should account for the variety of priced and non-priced goods and services frequently produced, even if these are difficult to quantify. As deforestation accelerates there has been a surge of interest in high profile uses such as the harvest of secondary forest products and tourism. Tobias and Mendelsohn attempt to quantify recreation value applying a zonal travel cost method to domestic visits to the Monteverde Cloud Forest Reserve (Costa Rica). In so doing, they attempt to demonstrate the economic value visitors assign to their visit over and above the price they already pay to access the reserve.

Their finding that the inferred tourist valuation of the reserve can potentially exceed the competing alternative by a magnitude up to two times is indicative of a current bias in economic appraisal, which largely ignores non-market benefits.

3.3.2 Data collection and field procedures.

Costa Rica is one of a number of countries synonymous with environmentally sound and carefully planned tourism (mainly to its protected areas). Located between 8 and 11 degrees north of the equator, a diverse terrain combined with tempering Pacific and Caribbean climatic influences assures a high biodiversity rating in a relatively small area (Chat 1992). Although wealthy relative to may of its Central and Latin American counterparts, land conservation to agriculture mainly coffee, bananas and livestock is a constant threat to the country's diverse ecological environments which include 24 National Parks. As is the case in many other developing countries, there is a need to justify resource commitments, which are perceived to have a high opportunity cost. Protected areas for the sake of biodiversity alone are rarely a convincing justification for foregone development benefits. The case for Ecotourism therefore needs to be convincing and provide a demonstrable return to the country.

The travel cost method infers the value user place on a recreational experience from their travel behaviour. Tobias and Mendelsohn use the zonal variant, which begins with the collection of address information of domestic visitors to the 10,000h2 private reserve (1988). Visitors are then zoned according to their canton (state) of origin and an average visitation rate for each zone calculated by dividing observed visits by canton population. Next zonal average visit cost is estimated. A composite cost estimate is derived based on a standard cost per kilometre (distance measured between the reserve and the main town of each canton) out of pocket costs, a fraction of fixed costs (ie wear and tear) and a value of travel time. The authors do not specify the fraction of the hourly wage rate they use to value travel time, but do emphasize the sensitivity of the final result to these initial cost assumptions. A total of 81 observations (corresponding to the number of cantons) are available to generate a typical demand function relating visitation rate to price (travel cost) plus extra available data on canton population density and literacy which are thought to affect observed visitation rates.

3.3.3 Results of the analysis

Estimating the demand function by regression analysis provides a downward sloping line of best fit in the cost (price) visitation rate (quantity) space (diagram). In deriving this demand curve some variables have greater explanatory power than others and as it turns out, a linear specification omitting the literacy variable best explains observed visits.

For each canton (observation on the price (cost) axis) a measure of the total consumer surplus is derived from the area above the price line and below the fitted demand curve: essentially a measure of the difference visitors from that zone paid to get to the reserve and how much the demand curve indicates they would be willing to pay. Note that the latter assertion is based on the strong assumption that visitors from all zones have identical tastes with respect to the site and react in the same manner with respect to costs. After calculating the consumer surplus for each canton, the authors sum over all cantons for a n annual consumer surplus of between US$97,500 and 116,200 depending on the constituents of the estimated function (and thus the slope of the curve).

It seems reasonable to suggest that Monteverde Reserve is unique and that its conversation would – provided the real value of recreation flow remains constant over time – signify a loss of the estimated surplus in perpetuity. This stream of annual benefit collapsed to its present value equivalent using an appropriate discount rate should thus represent the true economic value of the reserve. As time goes by, however, the rarity of rapidly disappearing rainforest suggests that demand for protected areas like Monteverde will increase. Rising demand implies increased visitation rates and a higher consumer surplus. The authors therefore suggest that simply to discount the future streams of benefits by a factor would underestimate the value of the site by discounting distant benefits at too great a rate. Using a growth rate as a proxy to increasing visitor value, a net factor r-a of these offsetting rates is taken as the appropriate factor to adjust benefit streams. The complex derivation of this factor is not discussed by the authors who opt for a rate of 4 per cent to translate the estimated consumer surplus perpetuity for Monteverde to a present value of between US $2.4 and 2.9 million. Alternatively dividing the annual consumer surplus estimate by the number of domestic visitors in 1988 yields a value of around $35 per person.

The estimated values do not include foreign visitor valuation of the reserve. The authors suggest that it is reasonable to assume the domestic valuation as a lower bound valuation by a foreign visitor who travels further and has fewer alternatives at home. On this basis the addition of foreign visitors inflates the site present value estimate to a range of $2.5 and $10 million. Opting for $8 million a value per hectare of $1250 is obtained by dividing over the 10,000 h2 of the reserve.

3.3.4 Discussion

How useful is this per hectare valuation? Conservation of Monteverde competes with agriculture in surrounding areas. The market price of agricultural land can often be interpreted as representing the present value of everything that can produced on it over time. A current price of land outside the reserve of between $30 to $ 100 per hectare therefore compares unfavourably to the per hectare recreational present value of $1,250. In other words, conversation to agriculture would incur an economic cost per hectare at least equal to the difference between the two options. Conversely the expansion of the reserve represents a well-justified investment from an economic and social perspective. Including other non-priced elements such non-marketed forest products and biodiversity values may further increase the return to conservation.

There are several caveats to the presented estimates, many of which are related to problems inherent in the travel cost approach. As already indicated the author's note to sensitivity of consumer surplus estimates to the assumptions underlying the composite cost per kilometre. Small changes to any of the elements that make up this cost effect the slope of the estimated demand curve and therefore estimated consumer surplus. Estimation error is notoriously common in the misspecification of the value of time spent travelling to the site and time on site. This debate hinges on the rationale that leisure time should be valued less than remunerated labour time or even at zero if the opportunity cost so dictates. A related problem alluded to in the paper, is that the benefit estimate derived from the demand curve relates to the whole trip experience and not just the on-site recreational benefit. A crude device often used to disentangle one site value from the value of he whole experience is to ask visitors to assign a percentage of enjoyment or purposefulness to specific visit components. This becomes more complicated when visitors take in several other sites en route to the site of interest or simply have difficulty disregarding travel as an essential and enjoyable part of the whole experience. Moreover, the assumption of an identical consumer surplus for domestic and foreign visitors to Monteverde to calculate the aggregate visitor consumer surplus range seems unlikely. Foreign visitors may indeed incur great cost getting to Costa Rica and have few areas similar to Monteverde nearer home. It is unlikely though that foreign visits are for a single purpose and therefore erroneous to assign the whole travel cost to any single site. Although the authors have assigned a conservative value to foreign consumer surplus, the issues of multipurpose visits need to be understood to avoid seriously biased benefit estimates.

While it is clear that methodological difficulties noted here need to be further addressed the current study begins the task of quantifying missing forest values.

Only as methods and measurement become more robust will the true value of forest resources be truly appreciated and possibly captured by their owners.

3.4.0 Case Study: Nigeria, Shelterbelts and Farm Forestry (Anderson 1987)

This study is a cost benefit analysis of the tree-planting programme already underway in the arid zone of northern Nigeria. Unsustainable use of fuelwood in the area (used by 90% of the population for cooking) is leading to a sharp decline in farm tree stocks, increased encroachment by farmers on public reserves, and the non-sustainable harvesting of trees in the more humid southern belt. These activities are reducing *soil fertility* through gully erosion, loss of topsoil, surface evaporation, reduced soil moisture, and the use of dung and residues for fuel rather than fertiliser.

The two main components of the afforestation project are shelter belts and farm forestry. Shelterbelts consist of lines of trees (usually eucalyptus and neem) arranged in 6 to 8 rows up to 10 km long. Farm forestry is undertaken by farmers on their own land, and typically 15-20 trees/ha are planted with the aim of providing useful products (fodder, fruit, fuel, shelter) for the household.

The analysis compares the financial and economic returns to shelterbelt and farm forestry project to a 'without project' base case. The benefits from afforestation include halting declines in soil fertility (plus any increases in soil fertility as a result of improved moisture retention and nutrient recycling), increased outputs of livestock products, and the value of tree products.

The benefits of livestock and tree products are valued directly by multiplying increase in quantity by the market price to derive their *financial* value and then adjusting this to reflect the *economic* value as appropriate. The value of wood and fruit from the new trees is estimated to be $22/ha for the shelterbelts and $7 for the farm forestry, net of labour costs.

Estimation of the environmental benefits of the rural afforestation programme is undertaken using the *production function approach.* The two main steps to this approach are discussed below.

1. Estimating the effect of the afforestation programme on soil fertility.

Estimates of the changes in soil fertility due to the afforestation programme were difficult to make due to insufficient data on soil fertility and on the direct and indirect impact of tree stock decline on soil erosion. Through discussions with agronomists and other soil experts, a rate of soil fertility decline of between 1%-2% per year was adopted in the analysis. These rates are applied to the gross value of farm output but not to costs (costs could increase over time if it becomes harder to work the land).

Following a review of the international research on the topic, it is assumed that the shelterbelts would increase the net yield of crops in the area by 15%-25%. The main mechanisms for this would be increased soil moisture retention and reduced crop losses from wind due to reduced wind speeds. For farm forestry, the increased yield is taken to be a more modest 5%-10%.

In the with project case the decline in soil fertility is gradually stemmed and soil fertility is enhanced as the afforestation programme begins to take effect (after 7-10 years for shelterbelts and 7-15 years for farm forestry). These 'with project' benefits are compared with the assumed trend 'without', which is a decline in soil fertility of 0%-2% per annum. This decline would be halted after 8 years with the project.

2. The benefits derived from changes in soil fertility are calculated by estimating the value of the changes in agricultural output. The estimates of financial and economic values of crop output under the three systems are made from traditional agricultural cultivation on a typical three-hectare farm, using information from local surveys undertaken during preparation of rural development projects and border price information from World Bank data.

The main investment costs of the programme included in the analysis are:

i. fencing and planting expenses -- $150/ha for shelterbelts and $40/ha for farm forestry;
ii. the opportunity cost of the farm land occupied by trees, taken to be proportional to the area taken up by the trees -- 12% for shelterbelts, 2% for farm forestry;
iii. Other farm forestry costs (e.g., setting up seedling nurseries, distributional facilities and an extension network).

3.4.1 Results

The NPV of alternative land uses under a 10% discount rate and 50-year time horizon, are presented in Table 3.1. For shelterbelts, a base rate IRR of about 15% was estimated. Sensitivity analysis on yield costs and underlying erosion produced a IRR within the range of 13%-17%, while a consideration of the wood benefits only showed an IRR of 4.7%. The base case for the farm forestry programme was an IRR of 19%, with a range of 15%-22% in the sensitivity tests. The IRR for wood and fruit benefits was 7.4%.

The timing of benefits is significant to the results. After Year 17, net farmer income without the shelterbelt programme declines to zero and it is assumed that the land is abandoned at this point. However, for the first 9 years of the shelterbelt programme gross farmer income with the project is less than 'without', because of the effect of taking land out of production to plant the trees.

Table 3.1 Costs Benefit Analysis of Shelterbelts and Farm Forest Project, Nigeria (NPV in Naira/ha)

	Shelterbelts	Farm Forestry
Base Case	170	129
Wood (and Fruit) benefits only	-95	-14
Low yield / High cost case	110	70
High yield case	221	na
No erosion	108	75
More rapid erosion	109	60
Soil restored (plus yield jump)	263	203

3.4.2 Discussion

Traditional CBA typically does not provide an economic justification for planting trees. This is because the environmental benefits are normally omitted and trees grow so slowly their benefits arise a long time into the future. Applying conventional discount rates to their stream of benefits tends to yield a low economic rate of return. As a result, afforestation schemes are usually undertaken in response to tax incentives, or are subject to special low discount rates (exceptions include rapidly growing species and trees planted for social and amenity purposes).

However, an environmental CBA can show very different results if it attempts to place economic values on the full range of forest benefits excluded in traditional CBA (e.g., indirect benefits of shade, windbreaks and soil retention). The above study was one of the first to demonstrate that afforestation can be justified according to conventional cost benefit criteria when the wider non-timber benefits of the forest are considered, despite the lags involved in the appearance of benefits. Merely considering wood benefits would not justify proceeding with the scheme.

The study is also an example of using the production function approach to estimate tree planting's soil fertility maintenance function. The estimates are based on a number of assumptions sensitive to local conditions and project parameters. These cannot be uncritically transferred from elsewhere and the study indicates what kind of information needs to be collected for appraisal purposes, and the importance of such analysis to the final results.

3.5.0 Case studies on the Economic Value of Medicinal Plants

3.5.1 Introduction

The *potential*returns from commercial drugs derived from plant species is one strong argument for identifying and preserving the world's biodiversity (particularly of species rich ecosystems such as tropical forests).

About 25% of all Western prescription drugs and 75% of developing world drugs are based on plants and plant derivatives (Principe, 1991). The pharmaceutical industry based on rainforest related drugs is estimated to generate about US$43 million in annual revenues. Clearly, medicinal plants are relevant to *use value* arguments for conserving biological resources. How far they have relevance in justifying conservation of biodiversity as such is more problematic.

Quantitative assessment of the medicinal benefits of plant species are highly speculative. Their value typically lies in undiscovered species of unknown uses that might have potential commercial value in the future. A difficulty then in valuing the potential returns from such species is that of assigning *ex ante* values to properties or products that have not yet been identified.

A further consideration is that because of the potentially significant *global importance* of uniquely rich tropical forest systems, the issue seems to be as much about what other, wealthier, countries are prepared to contribute to conserve biodiversity, as it is about their values within and for the countries where these resources occur. Valuation of such global values are at present highly speculative.

3.5.2 Valuation Methodologies used

Economic valuation of medicinal plants can be undertaken at two levels. Firstly, relating to the use value for commercial and traditional medicine. Secondly, relating to option value, the extent to which conservation is required to protect future use values of medicinal plants. Option value is reinforced by the extremely limited knowledge that exists about the medicinal properties of plants, and will partly depend on the nature of future research in the medicinal drugs sector with respect to the base materials that are likely to be used. There is some debate over the merits of natural product screening relative to biotechnology and chemical synthesis (some scientists believe that genetic engineering of micro-organisms will eventually displace plant-based research).

Notwithstanding the current difficulties surrounding the valuation of biodiversity, Pearce and Moran present a model for determining the medicinal value of a unit of land as biodiversity support.

The medicinal value of a given area, say a hectare, of 'biodiversity land' is:

$$V_{mp}(L) = p.r.a.\ V_i(D)$$

where:

p	the probability that the biodiversity supported by that land will yield a successful drug D
$V_i(D)$	the value of the drug where the subscript i indicates one of two ways of estimating the value: the market price of the drug on the world market ($i = 1$), or the shadow value of the drug which is determined by the number of lives that the drug saves and the value of statistical life ($i = 2$)
R	the royalty that could be commanded if the host country could capture the royalty value
a	the coefficient of rent capture

Each of these factors are described in more detail below.

The probability of success (*p*)

The probability of success, *p*, is based on discussions with drug company experts. Principe (1991) estimates that the probability of any given plant species giving rise to a successful drug is between 1 in 1000 and 1 in 10,000.

Estimates of the number of plant species likely to be extinct in the next 50 years vary, but a figure of 60, 000 is widely quoted (Raven 1980). This suggests that between 6-60 of these species could have significant drug values. Therefore conservation of tropical forest land might realise a benefit in terms of medicinal drugs equal to the economic value of these 6-60 species. Thus, 30 could be taken as the mean value of plant based drugs lost.

Table 3.2 Some Values of Plant-based Pharmaceutical

	$ billion 1990 (bracketed number refer to year to which estimate relates)		
	USA	OECD	WORLD
Market value of trade in medicinal plants	5.7 (1980)	17.2 (1981)	24.4 (1980)
Market or fixed value of plant-based drugs on prescription	11.7 (1985) 15.5 (1990)	35.1 (1985)	49.8 (1985)
Market value of prescription and over-the-counter plant based drugs	19.8 (1985)	59.4 (1985)	84.3 (1985)
Value of plant-based drugs based on avoided deaths:	120.0 (anti-cancer only) 240.0 (+ non cancers) (1985)	360.0 (anti-cancer only) 720.00 + non cancers (1985)	

Source: Pearce and Moran, 1994

3.5.3 Approaches to valuation (V_i (D))

Three approaches to valuation might be used: (i) the market value of the plants when traded; (ii) the market value of the drugs (based on plant material); or, (iii) the value of drugs in terms of their life saving properties, using a value of a *statistical life*

Each of the above valuation methods will give different estimates. Valuation based on life-saving properties give the highest values (using the value of a statistical life of $4 million (Pearce *et al*, 1992)), while the market price of traded plant material give the lowest values.

In the 1980s, an estimated 40-plant species accounted for plant-based prescribed drug sales in the USA. Based on the prescriptions values reported in Table 3.2, each species can be estimated at $11.7 billion/40 = $290 million on average. Principe (1991) suggests that USA 1990 prescription plant-based medicines have a retail value of $15.5 billion, which would raise the value per plant to $390 million. Assuming that all life saving drugs would be on prescription, use of the value of avoided deaths suggest a value per plant of $240 billion / 40 = $6 billion per annum.

By using these average estimates, it is possible to get some idea of the lost pharmaceutical value resulting from species loss, using 30 as the estimate of lost species of pharmaceutical potential.

Using market-based figures, annual loss to the USA alone would be 30 * $292 million = $8.8 billion, and to the OECD countries perhaps $25 billion. Based on the value of life approach the annual losses would be 30 * 6 billion = $180 billion for the USA, and over $5000 billion for the OECD countries (these figures might be compared to the GNP of the Brazilian Amazonia which is estimated at $18 billion per annum).

It should be noted that these figures assume that substitutes would not be forthcoming in the event that the plant species did become extinct.

The royalty (*r*)

Potentially useful medicinal products only acquire significant value after commercial processing in modern laboratories making it difficult for developing countries to realise these values. An important question is "What percentage of the eventual value should be attribute to their origins in the forest?" Historically, international patent systems have provided little protection for products based on natural goods. Thus, while indigenous knowledge of the medicinal value of plants and animal species is often fundamental to the development of commercial drugs, little economic benefit is returned to the indigenous communities.

Drug companies typically use specialist plant gathering agencies (e.g., botanical gardens and private companies) who in turn employ local institutions and people to collect and ship the products. Payment to the gathering companies is often by contract or weight of material, but there are examples of agreements involving royalties in the event of successful exploration which are divided between the gathering company and the source countries (these agreements provide for the sharing of rents as intended by the Rio Biodiversity Convention).

Royalties are usually based on the value of the drug to the Drug Company (ranging between 5-20%). Royalties are generally higher for plant materials to be used in a drug nearer to being marketed, as opposed to material destined for screening and longer term development. Based on existing royalty agreements of 5%-20% and given that royalties will be low for drug development some way into the future, a value of $r = 0.05$ is adopted in the model.

Rent capture (*a*)

The amount that a developing country can capture of the total value of biodiversity, in reality is significantly less than its total value. Historically the *capturable boidiversity benefit* was essentially zero but a number of recent institutional arrangements have made it now more likely that countries can capture some of the biodiversity benefit by attracting foreign funding for projects which promote conservation initiatives.

When using valuation approaches (i) and (ii) the *institutional capacity* of the host country to capture the values in the discoveries should be accounted for. Failure to so is likely to result in an exaggerated value to the host country. A factor representing the institutional framework should therefore be applied to the *ex-post* discovery valuation.

Ruitenbeek (1989) uses a Rainforest Supply Price to estimate biodiversity. This estimates the amount a developing country can capture, either through genetic product development or transfers from the international community, to justify saving a particular rainforest.

The factor will depend on: the licensing structure in the host countries; whether research in the host country causes other leakages in the economy; and, whether the ability exists domestically to follow out the research. This factor is therefore expected to be low in tropical low-income countries.

$$CPE = a.\ EPV$$

where CPV is capturable production value, EPV is expected production value, or the patent value of the discovery. If host countries could capture rents perfectly then $a = 1$. In reality a tends to be as low as 10% explaining why developing nations feel that the benefit of their efforts to conserve biodiversity is captured more by others. Therefore, a can be thought of as the coefficient of rent capture. A range of $a = 0.1$ to 1.0 is adopted in the model.

The value of land for medicinal plants

Based on the above figures, an estimate of the value of a representative hectare of land is derived, using the following model:

$$V_{mp}(L) = \{N_R . p.r.a. V_i / n\} / H \text{ per annum}$$

Where:

NR = number of plant species at risk

n = number of drugs based on plant species

H = number of hectares of land likely to support medicinal plants

NR = 60, 000

p = 1/ 10, 000 to 1/ 1000

r = 0.05

a = 0.1 to 1

V/n = 0.39 to 7.00 billion US$

H = 1 billion hectares, the approximate area of tropical forest left in the world

The resulting range of values is \$0.01 - \$21 per hectare. If a=1, then the range is \$0.1 - \$21/ha. The lower end of the range is negligible, however the upper end of the range would, at a 5% discount rate and a long time horizon, amount to a present value of around $420 ha.

Pearce and Moran conclude that despite the formidable data problems and the difficulties involved, the model developed indicates that values range from very low to around $20 per hectare. Estimates relating to other studies of biodiversity values are summarised in Table 3.3.

Table 3.3 Biodiversity: Some Results from Previous Studies

Study Area	Result	Valuation Technique	Source
Land for medicinal plants in general	$0.01 - $21 per hectare	Based on: $V_{mp}(L) = \{N_R.\ p.r.a.\ V_i / n\} / H\ p.a$ Where: p - probability that the biodiversity 'supported' by that land will yield a successful drug V_i - the value of the drug N_R = number of plant species at risk n = number of drugs based on plant species H = number of hectares of land likely to support medicinal plants and NR = 60, 000 p = 1/ 10, 000 to 1/ 1000 r = 0.05 a = 0.1 to 1 V/n = 0.39 to 7.00 billion US$ H = 1 billion hectares, the approximate area of tropical forest left in the world	Pearce and Moran, 1995
Korup National Park, Cameroon	Annual value of $85, 000, and per hectare values of $0.2 - $0.7	Expected Production Value Analysis (EPV) EPV = (value of research discovery) * (number of capturable research discoveries) CPV = k * EPV, 0 > k <1 where: CPV = Capturable production value; k = 10% The value per research discovery is based on patent values reflecting the expected gains to industries doing research in the area. It is assumed that the Cameroon will only be able to capture 10% of the genetic value through the licensing structure and	Ruitenbeek, 1989

		the institution in place.	
Mangrove resource in Buntuni Bay, Indonesia	$ 1, 500 / km^2 per year	Capturable biodiversity benefit if mangrove maintained intact	Ruitenbeek, 1992
Capturable benefit for ecologically important and diverse ecosystem such as a tropical forest	$3, 000 / km^2 per year	Analysis of transfers over the period 1987-1990	Ruitenbeek, 1990
Local medicinal plant use in Belize	Annual net revenues of $9-61 per hectare	Based on study of plant harvesting. Note that local values could become quickly depressed, if large tracts of land were devoted to medicinal plants.	Balick and Mendelsohn, 1992

Contingent valuation approaches are perhaps the most promising in terms of valuing biodiversity. Individuals can be presented with different ranges of species and habitats to see which they prefer. Information is obviously crucial for the success of such approaches. Many scientists believe that biodiversity is fundamental to human well-being while others argue that the functions of diversity are simply unknown. As such, individuals may not be well informed of the potential value of biodiversity.

Contingent valuation studies on the WTP for biodiversity *protection* do not provide information on the inherent value of biological diversity and are likely to underestimate economic value.

Travel cost and discrete choice studies might also be used for diversity valuation if it is possible to look at choices between alternatives that vary in their degree of diversity.

Even if the intrinsic value of biodiversity cannot be measured, there is still a very good reason for measuring the *direct use values of conservation:* biodiversity will be more prone to loss when direct use values are not appreciated.

There are many sustainable use values of habitat, such as ecotourism, and the collection of medicinal plants and non-timber forest products which might be valued. In addition, surveys measuring the foregone local use benefit as a result of designating a protected area, or tourists' willingness to pay for park maintenance provide some estimate of conservation values. Such conservation studies may include incidental diversity benefits if subjects (biological resources studied) are considered central to the system as a whole. There is then considerable scope for at least securing minimum values for biological diversity through the use of approaches focused on market values.

CHAPTER IV: SUMMARY, CONCLUSION AND RECOMMENDATIONS

4.1 SUMMARY

An appreciation of the economic and other values of biodiversity and its links with biotechnology is essential in evaluating options for the conservation and sustainable use of genetic resources. The leading model for attempting to value all the different elements of biodiversity is known as Total Economic Valuation (TEV).

Lessons from the selected case studies have shown that a very wide range of value estimates can be derived, depending on the technique used and what is being investigated. In general, three quite different `classes' of biodiversity value are usually estimated. The study adopted the following classes of values:

(i) **Biodiversity production values.** These are measures of the value of biodiversity within an economic production function, focusing on a `supply-oriented' approach to valuation. They are frequently used to estimate direct use values for forest products, for example, but the approach can also be used to estimate indirect uses such as ecological functions. In the terrestrial biodiversity literature, they often attempt to estimate the value of inputs to specific drugs or agricultural uses.

(ii) **Biodiversity utility values.** These are measures of the value of biodiversity within an economic utility function, thereby attempting to capture total consumer surplus or `demand-oriented' value. Contingent valuation techniques have been used to capture non- use values, or other techniques are used to value the final end-use benefits of biodiversity.

(iii) **Biodiversity rent capture values.** These are measures of how much value is retained or captured within a country or region, or by a particular interest group. The methods usually concentrate on one part of a `profit' function, and are more interested in identifying a specific profit share than in identifying total economic value. The estimates derived by such approaches may be quite small if there are local institutional weaknesses or failures that prevent benefits from being captured.

Lessons from Production Function Approaches: - The basic methods used for valuing local uses involve estimating the lost productivity or value in the absence of proper protection or conservation. The techniques applied are associated with some form of `shadow-pricing' of goods and services.

From a practical research perspective, a key lesson from these empirical studies is that analyses should be country specific focussing locally important goods and services. Proper identification and careful evaluation of these uses under different impact or conservation scenarios will provide important insights into the nature and relative scale of the benefits of conservation.

Another lesson from these empirical analyses is that the direct use values provide an important benchmark for other, less easily quantified, uses. Valuation of the direct uses provides an initial comparative basis for subsequent valuations of other goods and services. The availability of such baseline information is necessary, for example, to estimate `option values' for future uses. Also, the baseline information allows setting of management and research priorities after all of the valuations are conducted.

Lessons from Utility Function Approaches: - Analysts often focus on final end-use utility or value because of the `public good' nature of biodiversity. Public goods are those for which complete exclusion is not possible: many people can enjoy the benefits from a specific service without affecting the level of enjoyment of others. Biodiversity benefits are often thought to fall into this category, and many production function approaches can not deal adequately with the `public good' aspect of biodiversity.

Techniques that might be regarded as `utility-based' approaches are travel cost methods, hedonic pricing, willingness-to-pay [WTP] surveys. Contingent valuation is one example of a group of techniques used to estimate benefits, and methods for applying CV techniques have been well-developed in the realm of environmental cost-benefit analysis.

A key lesson from this study is that the design of the survey questions and the sample frame of the survey can have a significant influence on the values derived through contingent valuation. One difficulty of using CV in this context relates to `lexicographic preferences.' Lexicographic preferences exist where decision-makers are unwilling to accept any trade-offs for the loss of a good or service. The literature demonstrates that, where such preferences are prevalent, CV techniques require methodological adjustments.

Recent work suggests that lexicographic preferences for biodiversity may be widespread in developed countries and that, moreover, the actual `definition' or `understanding' of biodiversity differs sufficiently among respondents. CV techniques under such conditions are highly suspect unless they have been modified to take account of such preference structures.

Lessons from Biodiversity Rent Capture Approaches:- much of the variation in biodiversity values in the literature can be attributed to various attempts to measure biodiversity rents or profits. Different analysts use different definitions for rent or profit, and in some cases the profit includes a portion of the `consumer surplus' that final end-users would presumably be willing to pay for a given product. In all cases, however, the methods have invariably attempted to isolate the expected value of a single species of plant through tracing impacts through production functions, demand functions, and distribution functions.

In effect, these rent capture approaches can be thought of as a composite of the production and utility function approaches, with a particular view to isolating the rent or profit share that is captured by a specific interest group. A number of examples for terrestrial biodiversity valuation have focused specifically on capturing the consumer surplus component, and these often generate very high values.

Based on the impact on human lives saved, Pearce and Puroshothaman (1992) estimate biodiversity values of US$1.4 million per species and, using similar techniques, Principe (1989) generates estimates of US$31.8 million per species.

Other analysts have focused on producer surplus values or profits; Farnsworth and Soejarto (1985) used a profit function to derive expected biodiversity values from pharmaceuticals of US$3.5 million per species based on drug sales. Refinements on this approach using similar techniques have generated estimates of US$10,000 per species (McAllister, et al., 1991), US$785 per species (Pearce and Puroshothaman, 1992) and US$635,000 per species (Principe, 1989).

Finally, other analysts have focused on rents or profits captured by the original owners of a product or technique. These techniques are based on actual values captured or capturable through existing patent or royalty schemes and were first developed by Ruitenbeek (1989), generating values of the order of US$20 to US$200 per species. Subsequent refinements of these methods still demonstrated that royalty-based mechanisms generate the lowest estimates: US$339 per species for drug sales (Harvard Business School, 1992); US$72 to US$62,000 per species for a range of terrestrial bioprospecting (Reid, et al., 1993).

4.2 CONCLUSION

The case studies presented include a wide range of methodological issues and Valuation techniques in varied geographic settings, although their coverage cannot be claimed to be exhaustive in any way. Several observations emerge from reviewing these studies. First, the importance of integrating ecological and economic approaches is critical, especially when the valuation of ecological functions is the objective. This requires more than complex mathematical techniques, but extends to continual collaboration between all the stakeholders. The studies also demonstrate that valuation should not be conceived as an end in itself, but needs to be directed towards some policy issue. These issues may range from simply raising awareness of the importance of biodiversity to choices among alternatives to meet some stated policy goal, with protecting biodiversity representing just one option.

A variety of valuation techniques are also shown in the case studies, and some clear patterns emerge. Numerous environmental economists have attempted to estimate the value of genetic resources, resulting in wildly disparate estimates ranging over six orders of magnitude. For instance, in valuation of medicinal plants, estimates range from a low of $15 to $150 per species, based on actual values captured or capturable through existing patent or royalty schemes, to a high of $23.7 million per species based on the impact on human lives saved through drug development. This value estimate raises concerns for many of the role of the private sector contribution to biodiversity conservation. In addition to the limit costs of the genetic resources, there is also the concern that the long-term conservation efforts.

The absence of market data and the need to value biodiversity in developing countries will put pressure on researchers and policymakers to use and improve valuation methods for estimating the value of biodiversity rich land.

Some important aspects of this research would include the following: production function approaches to valuation of a small number of local direct and indirect uses can provide a useful benchmark for other valuations. Utility function approaches, and contingent valuation in particular, can provide useful insights into non-use and other values that are associated with the `public goods' nature of products, services or information derived from genetic resources. Care must be taken in designing surveys to accommodate lexicographic preferences. Rent capture approaches can be used to isolate the expected biodiversity value of individual species. In doing this, care must be taken in identifying the institutional context (or revenue sharing context) and in recognizing that much of the `value' may in fact be associated with information rather than physical products.

4.3 RECOMMENDATIONS

- Further research is required to improve widespread applicability of Contingent Valuation method in developing countries.
- Valuation should not be conceived to be an end to itself, but needs to be directed towards some policy issue. These issues may range from simply raising awareness of the importance of biodiversity to choices among alternatives to meet some stated policy goal, with protecting biodiversity representing just one option.
- There is need for more integrated valuation methods.

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Table 2.1. Total Economic Value of biological resources.

	USE VALUE		+	PASSIVE OR NON-USE VALUE(1)
DIRECT + VALUE	**INDIRECT + VALUE**	**OPTION + VALUE**	**(QUASI + OPTION VALUE)**	**EXISTENCE VALUE**
Provision of basic resources: food, medicine, construction materials, nutrients.	Providing support for economic activity and human welfare, e.g. watershed protection, waste storage and recycling, maintenance of genetic diversity and erosion control. Providing basic resources: e.g. oxygen, water, genetic resources.	Preservation of future direct and indirect use values		
Non-consumptive uses: recreation			Conservation of yet unknown future uses	Forests as objects of intrinsic value, as a bequest, as a gift to others, as a responsibility (stewardship). Includes cultural, religious and heritage values.
Plant genetic resources	Providing information benefits such as scientific knowledge.			

***Source**: Pearce, D.W. 1990. An Economic Approach to Saving the Tropical Forests. LEEC Paper DP 90-06. IIED, London; and Perrings (ed.) 1995. The Economic Value of Biodiversity, in Heywood, V.H. 1995, Global Biodiversity Assessment, UNEP, Cambridge University Press, UK.*